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CHILD DEVELOPMENT

In this number there are reports of studies of language development, of emotional tensions, of learning under unusual stimulation and transfer in motor learning.

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VOLUME III NUMBER 3

CHILD DEVELOPMENT

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The Development of Language in Twins

I. A Comparison of Twins and Single Children[1]

ELLA J. DAY

INTRODUCTION

IN THE year 1886, Horatio Hale (17) in a paper published in the Proceedings of the American Association for the Advancement of Science, reported the case of a pair of twin boys who were so retarded in speech that members of the family could not understand them. These children lived in Boston in 1860. According to the report of an aunt, who visited them frequently, they developed a twin language so unlike English that they could not be sent to school because no one could understand them. Observation of the occasional development of such a special language by twins, suggested the problem of research undertaken here. The twin situation is, from an environmental point of view, quite unlike that of single children and it seemed possible that this might be a factor of considerable significance in the development of language.

[1] From the Institute of Child Welfare, the University of Minnesota, The Development of Language in Twins, Part II, The Development of Twins: Their Resemblances and Differences will appear in a subsequent issue. This will include a discussion of the mental development of twins, and a comparison of the types of twins in intelligence, language development and certain physical traits.

McCarthy's (13) investigation "The Language Development of the Preschool Child" provided an excellent basis for comparison. This study was completed in the summer of 1928 at the Institute of Child Welfare of the University of Minnesota. Dr. McCarthy selected 140 children (20 at each 6 months age level from 18 to 54 months) on the basis of sex and socio-economic status. She visited them and recorded 50 consecutive responses made by each child while he played with a group of toys that she presented to stimulate speech. These data were than analyzed in four different ways: by mean length of response; according to the Piaget functional analysis; by the grammatical construction of the sentence; and a word analysis by parts of speech. In brief the results indicated the developmental changes with age in agreement with other studies, as well as sex differences in favor of the girls. Differences in favor of the upper occupational groups were indicated also in each method of analysis. In the foreword to this study Dr. John E. Anderson says "On the basis of the number of controls utilized in the selecting of subjects and the care and thoroughness with which the data are analyzed, this monograph stands out as one of the best studies

of the development of language which has yet appeared." Thus the present investigation was planned to repeat the McCarthy technique using twins.

PURPOSE

The purpose of this investigation was to compare the development of language in twins with that of singletons of the same ages, sex, and socio-economic status.

2, 3, 4 and 5 years. Since McCarthy reports that 74 per cent of the responses of the 18 months old children were incomprehensible, it seemed adequate from the standpoint of the methods of analysis to be used, to begin with the 2 year age group. The wisdom of carrying the group on through the fifth year was not so apparent at the time the selection was made as the results now show it to be. An equal number

TABLE 1

Distribution of cases by age, sex and occupational class

OCCUPATIONAL CLASS	2 YEARS		3 YEARS		4 YEARS		5 YEARS		ALL (NUMBER OF PAIRS)	TWINS	MINNEAPOLIS POPULATION	MC CARTHY SINGLETONS
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls				
										per cent	*per cent*	*per cent*
I	1	1	2	0	0	2	1	1	4	5.0	5.4	5.0
II	2	0	1	1	0	2	0	2	4	5.0	6.3	6.4
III	7	9	8	8	10	6	9	7	32	40.0	37.3	35.7
IV	6	4	4	6	4	6	3	5	19	23.8	24.3	25.7
V	2	4	3	3	1	5	3	5	13	16.2	14.9	15.7
VI	2	2	2	2	4	0	4	0	8	10.0	11.8	11.4
Total....	20	20	20	20	19	21	20	20	80	100.0	100.0	100.0

SELECTION OF CASES

Through the courtesy of the Minneapolis and St. Paul Departments of Health, the writer had access to the birth registrations. The date of birth, sex, place of birth, name of physician attending the birth and the father's name, address and occupation were all recorded on the registration cards.

Subjects

Age and sex. After consideration of the findings of the McCarthy study, it was decided to select 80 pairs of twins, 20 pairs at each of four age levels, of boys and girls at each age were selected except at age four (see table 1) where there are 19 boys and 21 girls. These age groups are discrete because the records were taken within one month of the birthday. With the exception of one case where the records of the two children were not taken on the same day, the greatest deviation from the birthday was 38 days and the mean deviation for the whole group was 19.69 days. The one exception referred to deviated 99 days from the birthday.

Socio-economic status. The importance of securing a representative

sampling of the population is clearly brought out in such studies as the McCarthy study and the Goodenough (9) evaluation of the Kuhlman-Binet tests for children of pre-school ages. The sampling was made according to the Goodenough (10) classification of the Minneapolis population which was based on the application of the Barr Scale for Occupational Intelligence and the Taussig industrial classification to the 1920 census report of the occupations of males in Minneapolis between the ages of 21 and 45 years. The occupational levels are grouped into a six-fold classification. Group I consists of the professional vocations; group II the managerial occupations; group III the retailers, salesmen and skilled workmen; group IV the semi-skilled workmen; group V the drivers, helpers, etc.; group VI the day laborers. Table 1 shows the percentage of each occupational class found in the Minneapolis population and the percentages represented by the twins and singletons.

The distribution of the sexes is not equal at each occupational class but is equal in the upper three and lower three classes at each age, except at age four.

METHOD OF OBSERVATION

The language record

Just as the selection of cases was made on a basis similar to that used in the McCarthy study, the technique of obtaining the language record was carried out as it was with the singletons. A group of toys consisting of two linenette picture books, one of familiar animals and one of Mother Goose, a very small automobile, a rubber ball, a pasteboard cat that meowed when squeezed, a telephone with a bell, and a small music box were shown to the children to stimulate speech. In so far as possible, McCarthy's toys were duplicated exactly. The examiner requested to see each child alone but this was not always possible. The children were permitted to open the suitcase and look at the toys as they wished. The examiner remained out of the situation as much as possible because spontaneous responses were desired. Some conversations between the examiner and the child however always occurred. When members of the family insisted upon remaining in the room, they sometimes facilitated spontaneous speech on the part of the twin and sometimes interfered with obtaining an accurate record.

Fifty consecutive verbal responses were recorded and the time noted. The responses were recorded exactly as they sounded to the examiner. A response was denoted as complete when a distinct pause occurred. A complete sentence was always considered as a single response, although a single response might be either a complete or incomplete sentence. The mean time for obtaining such a record was 14.9 minutes for the twins as compared with 19.3 minutes for the singletons. The shorter time required by the twins is probably due to two factors. In the first place, they said considerably fewer words in the fifty responses. In the second place, the examiner was in the home anywhere from one to two and a half hours and at least one of the children had a somewhat greater opportunity to become adjusted to the presence of a stranger.

The examiner practiced taking such records with a group of children attending the nursery school at the University of Minnesota, preliminary to taking any records with the twins. She also had the advantage of being able to talk with Dr. McCarthy frequently and so check on minor differences in procedure.

The Intelligence tests

The Goodenough (18) drawing test of intelligence was given by the examiner to all the twins. This test consists merely in having the child draw a man. It is non-verbal and very simple to give. The results however were not useable since such a large percentage of the twins had not manipulated pencil and paper before and therefore they only scribbled.

The department of mental testing of the Institute of Child Welfare volunteered to give the twins the Minnesota Pre-school Scale, (11) which at this time was in the process of standardization. This test was devised by Goodenough and is a revision, for the most part, of the tests for these ages in the Kuhlman-Binet and the Stanford-Binet tests. Test results were obtained on 123 of the 160 children. A full discussion of these results will be presented in Part II.

METHODS OF ANALYSIS

McCarthy's methods of analysis were duplicated exactly. A total of 7,836 responses were made and of these 7,156 or 90 per cent were comprehensible and 780 or 10 per cent were classed as semi-comprehensible or incomprehensible.

Length of response

The comprehensible responses were analyzed first according to length of response. McCarthy set up the following arbitrary rules for this analysis:

(1) Contractions of subject and predicate like "it's" were scored as one word.
(2) Contractions of the verb and negative like "can't" were scored as single words.
(3) Hyphenated words and compound nouns functioning as single words like "Mother Goose" were scored as one word.
(4) Each part of a verbal combination was scored as a separate word.
(5) "Lookit" which occurred frequently was scored as one word if used alone although if followed by an object it counted as two words.

Functional analysis

According to Dewey the primary motive of language is to influence the activity of others. Young children in particular use language as it relates to their needs and give little heed to the adult usage of grammatical constructions and parts of speech. Piaget (16) working at the Institute Rousseau in Geneva developed such a functional classification which with slight revision was used by McCarthy:

A. Egocentric speech
   1. Repetition or echolalia
   2. Monologue
   3. Dual or collective monologue
B. Socialized Speech
   1. Adapted information
      (a) Naming
      (b) Remarks about the immediate situation
      (c) Remarks associated with the situation
      (d) Irrelevant remarks
   2. Criticism

3. Emotionally toned responses
4. Questions
5. Answers
6. Social Phrases
7. Dramatic imitation

Construction analysis

Until one undertakes the analysis of his own speech, or that of other adults, the extent to which adult speech falls short of grammatical standards of construction is scarcely realized. Many of the responses made in adult conversation are not structurally complete sentences, though because of what every adult knows to be implied, they are accepted in good everyday usage. The child patterns after the adults about him since as yet he is neither reading nor writing. For this reason McCarthy first divided the responses into the two groups complete and incomplete but included under the forms of complete sentences a group which were functionally complete but structurally incomplete. The outline of the classification used in this type of analysis is as follows:

A. Complete Responses
   1. Functionally complete but structurally incomplete responses
   2. Simple sentences without a phrase
   3. Simple sentences with a phrase
   4. Compound sentences
   5. Complex sentences
   6. Elaborated sentence, two phrases, two clauses or a clause and a phrase

B. Incomplete Responses
   1. Omission of the verb
   2. Omission of the subject
   3. Omission of a preposition
   4. Omission of a conjunction
   5. Omission of the verb and the subject
   6. Miscellaneous omissions (itemized)

Word analysis

Neither the McCarthy investigation nor the present study are primarily studies of the child's vocabulary. The nature of the experimental situation itself controlled somewhat the words the child used. For instance, by far the largest proportion of nouns used were the names of the toys and pictures shown the child. However, because of the number of children, and their selection, as representative of the Minneapolis population, an analysis of the words, according to the parts of speech, seemed warranted from the standpoint of showing their relative use, in a sample of running conversation.

The rules adopted by McCarthy for determining the number of different words used are similar to those developed by Bateman (1): They are as follows:

1. Include no proper nouns.
2. Include no plural form unless the singular was not used.
3. Include all forms of pronouns.
4. Include no variations of verbs or of adjectives unless they are from a different root.
5. The same word may be listed more than once according to its grammatical use; i.e., if a word is used as a noun and also as a verb, it is included twice.

RELIABILITY

Method of observation

In order to get some estimate of the degree of accuracy in recording such a verbal record, Dr. McCarthy, the examiner, and one other observer took records simultaneously, 25 responses

in length, on 10, two to five year old children, from a settlement house.

Table 2 shows the coefficients of reliability found between each two observers. The examiner first analyzed the language records as to length of response, the functional classification, and the construction of sentence category, just as the original data had been treated. The Spearman method of rank differences was used to determine the coefficients of reliability. In length of response the mean for each child according to each observer was used for the correlation and in the other analyses the percentage of whatever item was being correlated was used.

These coefficients seem sufficiently high to indicate reliability of the method of recording.

TABLE 2

Reliability coefficients on the method of recording

	OBSERVERS			
	1 and 2	1 and 3	2 and 3	Mean of all
	p	*p*	*p*	*p*
Mean length of response	.98	.99	.99	.99
Naming	.90	.99	.94	.94
Remarks about immediate situation	.95	.87	.94	.92
Functionally complete but structurally incomplete	.92	.91	.99	.94
Simple sentences	.32	.69	.72	.57
Incomplete sentences	.65	.40	.87	.64

Methods of analysis

The reliability of the various methods of analysis used in treating the language records was not determined in this investigation since McCarthy had determined this and found it to be high.

COMPARISON OF DATA ON LENGTH OF RESPONSE: TWINS AND SINGLETONS CHRONOLOGICAL AGE

The mean length of response is based upon a distribution of the responses. varying in length from one to nineteen words rather than upon a distribution of each child's mean length of response. Figure 1 shows a surprising difference in rate of language development for twins and singletons. At two years the difference is small but appears to become increasingly greater with age and is consistently in favor of the singletons. The mean length of response for the five year old twins is slightly below that of the three year old singletons. A retardation of two years in language development, one would think, was a serious handicap since contacts with our fellowmen depend so largely upon our ability to make ourselves understood verbally.

Critical ratios D/σ_D, computed for each age level were high and increased with age. At two years the ratio was 4.9; at 3, 11.6; and at 4, 15.3. Hence the superiority of singletons to twins in

language development is highly significant statistically.

Smith's investigation (18) of the development of the sentence and the extent of vocabulary in young children agrees very closely with the McCarthy results, and so only further emphasizes the handicap of the twins. The most rapid gain in length of response is made between two and three years by both twins and singletons. Although twins gain only one word in the entire year, singletons gain more than one word in the first half of the year. This difference in rate of development remains relatively the same up to five years. Smith feels that the relatively little gain in length of sentence after four or four and one-half years indicates that the sentence length has little value as a measure of sentence development after this age.

The question immediately arises as to when the curve of development for the twins turns and reaches the level of that of the singletons. Does the greater contact with other children, which occurs upon entrance in school, at or soon after the fifth year, stimulate language development sufficiently to give the twins this needed spurt? Does the twin situation so limit the child's environment in the early years of rapid development that he is always at a disadvantage? What is responsible for the retardation, heredity or environment, or both?

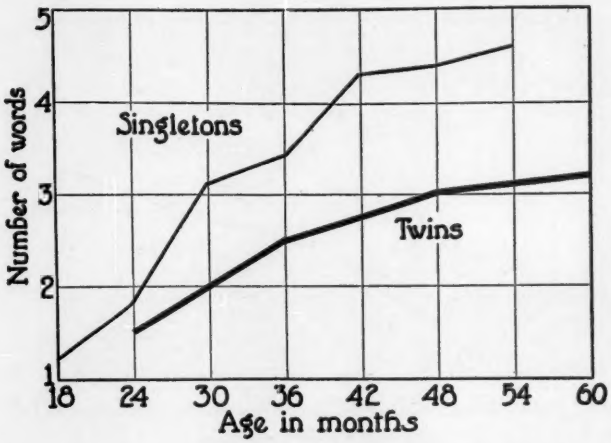

FIG. 1. MEAN LENGTH OF RESPONSE OF SINGLETONS AND TWINS BY CHRONOLOGICAL AGE

All of these questions and many more are as yet unanswered. Nevertheless the author has attempted to get what evidence she could to throw light on the problem.

Part II is devoted to a discussion of the mental ability of the twins but attention may be called at this time to the fact that the mental ability as well

as the language development of the twin group appears to be below average. The mean I. Q. for the whole group is 94. This is based upon the results of the Minnesota Pre-school Scale. The singletons, with whom the twins are compared have a mean I. Q. of 103.3, after the correction recommended by Goodenough has been applied. This correction is a subtraction due to Goodenough's observation that the Kuhlman-Binet test (the test used for the singletons) tended to score too high at the early ages. The singletons then appear to have been a group slightly superior even though they were so carefully selected. Had they been an average group the differences would be slightly decreased. That the twin group deviates even farther from normal is quite true although the evidence seems to be that this is a normal phenomenon rather than a matter of selection.

SEX DIFFERENCES

In agreement with the findings of McCarthy, Nice (15), Gale (6), Mead (14), Terman (20), and Doran (4), this reveals sex differences in favor of the girls. (See figure 2.) These differences are less marked than in the group of singletons at every age except four years, but are consistently in the same direction. It may be noted that at two years the twin girls are slightly superior to the single boys. The twin boys make a greater gain between two and three years than do twin girls but gain less thereafter. The differences between twin boys and girls at five years is greater than at any other age, while the greatest differences between the sexes in singletons was found at

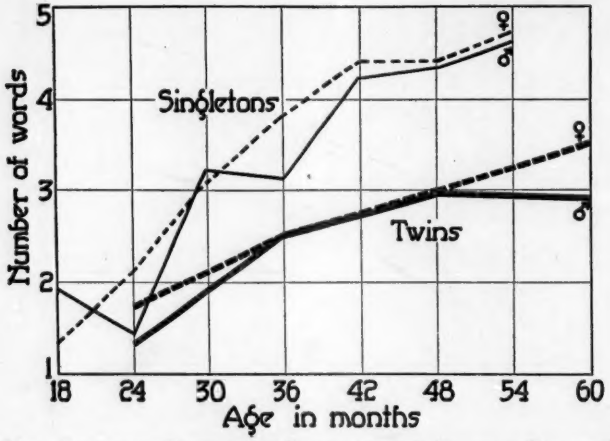

FIG. 2. MEAN LENGTH OF RESPONSE OF SINGLETONS AND TWINS BY SEX AND CHRONOLOGICAL AGE

two and three years. Smith does not report a consistent sex difference.

PATERNAL OCCUPATION

Because of the unequal number of cases in each of the six occupational classes the differences between occupational classes is most fairly shown by dividing the age groups into the upper three and lower three occupational classes. By so doing an equal number of cases and an equal number of each sex appears in each group. Figure 3 shows the expected differences between these groups. In comparing these results with the McCarthy results it must be noted that the age groups are not strictly comparable. The singletons were so grouped in reporting these findings that the age groups become 18, 27, 39 and 51 months, rather than at the exact year levels of the twins. The differences between twins and singletons are even more striking when based upon distribution by occupational class. That the singletons of the lower occupational groups are consistently above the twins of the upper groups presents a surprising picture of retardation. The mean of the differences at each age between upper and lower groups is .90 words for the singletons, .85 words for the twins so that the differences between upper and lower groups remain relatively the same. The fanning out of curves of the upper and lower group twins indicates that the difference increases with age, which

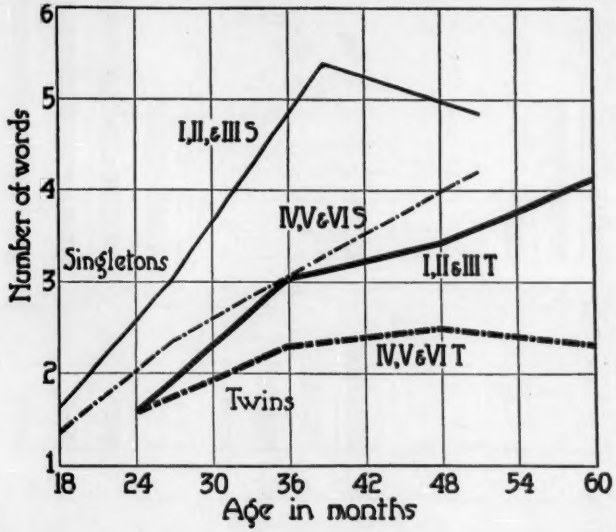

FIG. 3. MEAN LENGTH OF RESPONSE OF SINGLETONS AND TWINS BY UPPER AND LOWER OCCUPATIONAL GROUPS AND CHRONOLOGICAL AGE

suggests that environment plays a rôle in this.

COMPARISON OF DATA ON FUNCTIONAL ANALYSIS; TWINS AND SINGLETONS

The percentage of responses of the functional classification were worked out both inclusive and exclusive of the incomprehensible responses. Figure 4 shows the percentages of this classification based on all responses, including the incomprehensible responses.

When considered from the standpoint of age groups the incomprehensible responses, though somewhat fewer for twins at two years are slightly greater at three and four years and are still in evidence at five years. With the marked retardation in language development indicated by the differences in mean length of response of twins and single children, one might expect a very much greater percentage of incomprehensible responses on the

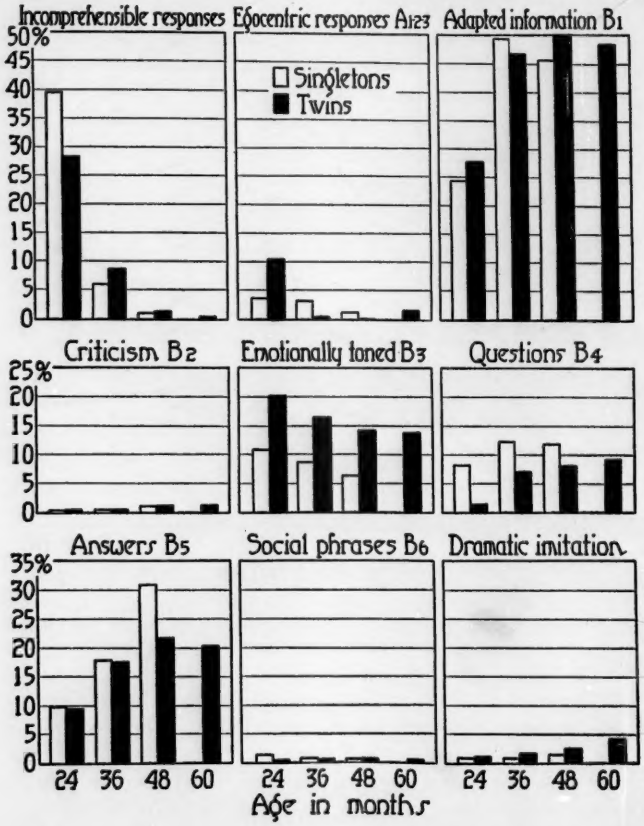

FIG. 4. FUNCTIONAL ANALYSIS OF SINGLETONS AND TWINS BY CHRONOLOGICAL AGE

part of the twin. Such responses do seem to persist for a longer time in the twins, however, which is suggestive of a slower development. Two factors in the twin situation may have acted to reduce somewhat the percentage of incomprehensible responses. It may be easier to understand short statements as compared with long ones and the twin data are composed of many more single word responses. Also, the examiner had had, just previous to making this study, two and one half years nursery school experience and was quite accustomed to interpreting the speech of young children. Dr. McCarthy on the other hand had had only the contact any adult may have with children previous to collecting her data.

The 780 incomprehensible responses include 83 semicomprehensible responses. Of 697 responses actually incomprehensible 287 or 41 per cent were single syllables, 121 or 17 per cent repetition of the same syllable and 289 or 42 per cent a series of different syllables. At two and three years the single syllables slightly exceed the others in number. At four and five years the series of different syllables is in the lead, in fact at five years, it is the only one represented. This type of incomprehensible response is no doubt a poor attempt at adult speech but the single syllables and repetition of the same syllable may be the voice play similar to that practiced by the young infant.

The three types of ego-centric responses described by Piaget are grouped together because each one appears to such a small extent. The twins, though they show more of this type of speech than the singletons at two years, show considerable less at three and four years, with an increase at five years. The twin situation of constant companionship, one might expect, would not be conducive to extensive ego-centric speech but rather to socialized forms of speech.

The different types of socialized speech are best presented in figure 5 where adapted information is divided into its sub-heads of naming, remarks about the immediate situation, remarks associated with the situation, and irrelevant remarks. Here too all percentages appear slightly increased since they are based upon comprehensible responses only.

Though as a whole adapted information shows increase with age and percentages in fairly close agreement with the singletons, when the four types of adapted information are considered separately differences between twins and singletons show up. Naming, the first type scarcely shows any decrease while with the singletons there is a marked decrease. That this function of language, typical of the two year old singletons but not so much so of the four year olds, persists through five years in the twins is indicative of maintenance of early language habits after they should have been dropped.

Remarks about the immediate situation increase with age but are present in greater numbers in twins than in singletons, whereas remarks associated with the situation are very few in number as compared with singletons, show relatively no increase with age, and do not appear at all until three years. In consideration of these two differences, one may wonder whether the limitations of the twin environment may account for these differences.

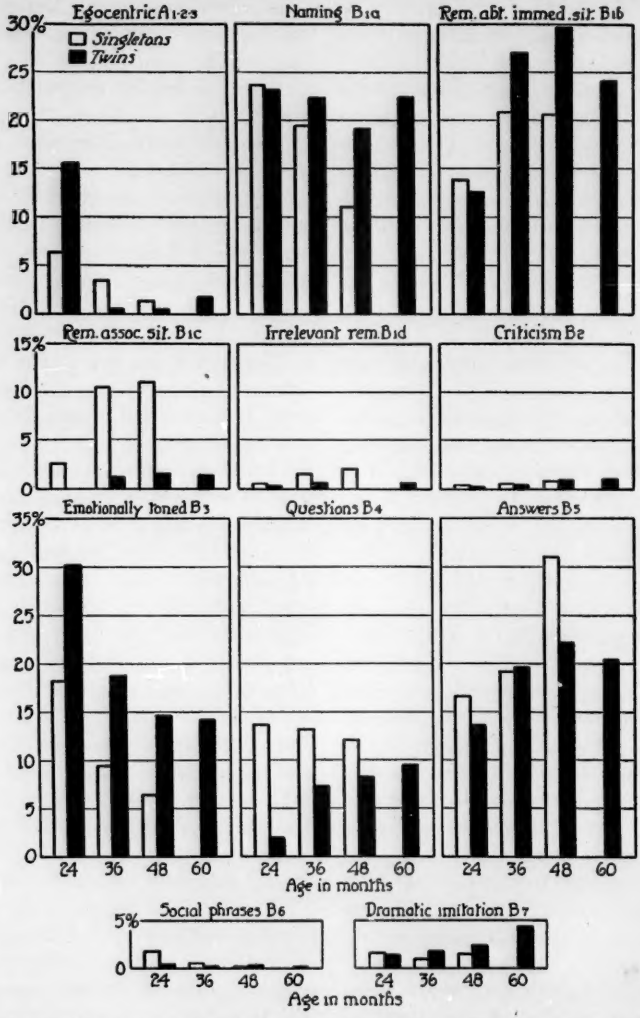

FIG. 5. FUNCTIONAL ANALYSIS OF SINGLETONS AND TWINS BY CHRONOLOGICAL AGE (BASED ON COMPREHENSIBLE RESPONSES)

The percentages of irrelevant remarks are comparatively insignificant. The singletons show a slight increase with age, however, which the twins do not show.

Criticism shows close agreement between twins and singletons and does increase with age.

The emotionally toned responses show one of the most striking differ-

ences between the two groups. Twins have almost double the per cent of the singletons at every age. Both show a decrease with age. This, like naming, is suggestive perhaps of persistence of infantile habits of language.

Questions increase with age in the twins but even at five years have not attained the per cent shown by singletons at two years. This no doubt is somewhat indicative of the retarded language development as well as of a high degree of satisfaction from companionship rather than from investigation of the environment.

Answers also increase with age but neither increase as much nor are present to so great an extent as with single children. This can not be attributed entirely to retarded development, however, since the extent to which the examiner asked the child questions determined to a considerable extent the percentage of answers given.

Social phrases though very much less at two years are slightly less at three years for twins than for singletons and greater at four years. Close companionship may be a factor here in reducing the need for such phrases.

Dramatic imitation increases very much with age and appears to be of greater significance in twins than in singletons. The social advantages of the twins through their companionship may bring this out somewhat more.

In considering the functional analysis as a whole it may be pointed out that the twins show retardation in those phases of the analysis which show the greatest developmental changes with age such as naming, emotionally toned responses, and questions. In ego-centric responses and dramatic imitation, however, they appear in advance of the singletons. These last two phases may easily be the result of close companionship.

As with the singletons, girl twins show some superiority over the boys in those items which make the greatest change with age. Comprehensive tables for these items are too detailed for publication. A large difference between boy and girl twins in incomprehensible responses at two years puts the girls quite inadvance of the boys. At three and four years the girls have a slightly greater percentage of incomprehensible responses, and at five they have less but these differences are so slight and the total percentage at three, four, and five years so small that the reversion is probably due to selection of cases.

The girls also show less ego-centric speech at every age except five years. The differences are small, however, except at two years, which is the most significant age from the standpoint of total percentage of this type of response.

In naming, the boy twins increase slightly while the girls decrease from the second to fourth year and then increase at five years. Girls have somewhat greater proportion of remarks about the situation and both boys and girls increase with age to four years then drop a bit at five years.

Girls increase more and are superior at all ages in remarks associated with the situation.

Emotionally toned responses are decidedly greater for the girls except at age three where a difference of only one per cent is in favor of the boys. The greatest differences in percentage of questions occurs at two years and is in favor of the girls. The other phases

of the functional analysis though they show some differences between the sexes show no striking or consistent trends.

The chief phases of analysis which showed marked differences between the upper three and lower three occupational classes are incomprehensible responses, ego-centric speech, questions, and remarks about the immediate situation. The greatest difference in incomprehensible responses is at two years where the upper class twins show about one-half as great a proportion as the lower class. Just the reverse situation is found in ego-centric speech. The lower group have slightly less than twice as much as the upper group at two years, and have none at all at the other ages. This was also the case with the singletons, except at thirty-nine months, where the lower group exceeded the upper group by quite a large proportion. Perhaps the sampling is not sufficient for these differences to mean a great deal since the percentage at any age is not very great. In both questions and remarks about the immediate situation the differences are not so marked at two and three years but become increasingly so at four and five years. The lower group shows a smaller proportion of these than the upper groups. A similar situation was found with singletons in regard to questions but not in regard to the other phase.

COMPARISON OF DATA ON CONSTRUCTION ANALYSIS: TWINS AND SINGLETONS

Chronological age

Figure 6 again shows that twins are retarded in language development as compared with singletons. Since they were found so retarded when measured by length of response one could scarcely expect to find them using many of the more complex forms of the sentence. It may be said, however, that in general the same tendencies with age are indicated in both the twins and singletons.

The functionally complete and structurally incomplete responses though they decrease with age are present to a somewhat greater extent in twins than in singletons. This group as has been stated, consists very largely of the single word responses. Although such responses appear rather commonly in adult speech they appear there largely in conversational usage while the young children employ them in other ways. For instance, in looking through the picture books it was not uncommon for the children to point at and name objects, and use no sentence at all. Twins evidently maintain this rather infantile manner of talking about what they see longer than do single children.

The simple sentence and all other forms of complete sentences increase with age but at every age are present to a considerably less extent than they are in singletons. The more complex the form of the sentence the greater the relative differences between twins and singletons become.

Incomplete sentences while not always present to a greater extent than in singletons do not drop off as rapidly. This again indicates persistence of early modes of talking or of rather infantile language habits.

The sex differences in sentence structure are not as marked for twins as singletons. There is no consistent

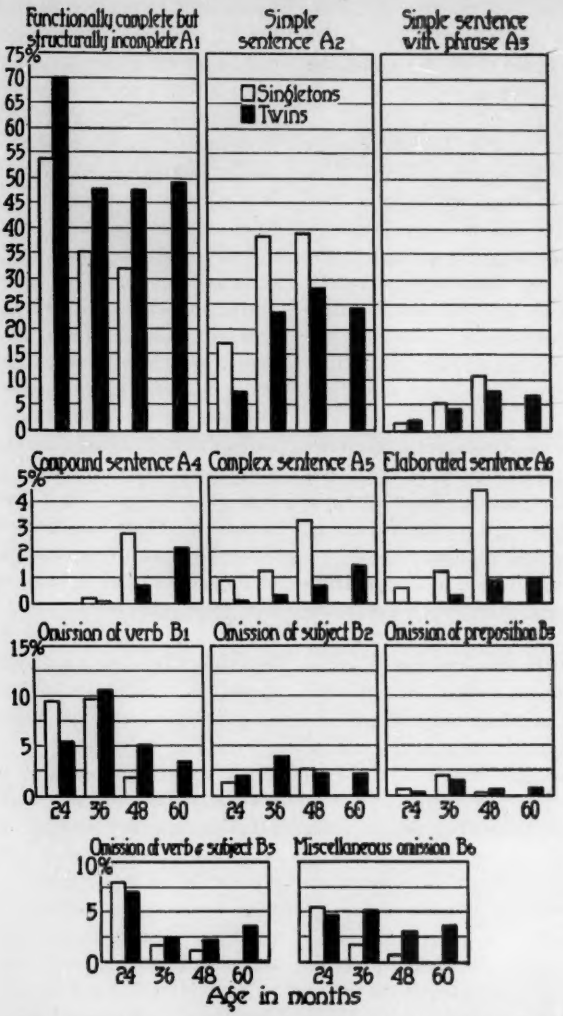

FIG. 6. CONSTRUCTION ANALYSIS OF SINGLETONS AND TWINS BY CHRONOLOGICAL AGE (EXCLUSIVE OF INCOMPREHENSIBLE RESPONSE)

trend in the differences between the boy and the girl twins in any of the items of the classification. It may be noted, however, that the girls do show all the forms of the complete sentence earlier and in larger proportion than the boys. Probably these items show the most important de-

velopmental changes with age and thus the girls may be considered in advance of the boys since they are using the more complex forms of the sentence earlier.

In relation to the singletons both boy and girl twins are retarded. In fact, as in the length of response, the girl twins rank below the boy singletons in practically all classifications of construction. Both sexes show the continuance of the functionally complete but structurally incomplete responses in much greater proportion than do singletons of the same age and sex.

When the responses are considered from the point of view of occupational class and construction of the sentence the differences are again found in favor of the upper groups.

The functionally complete but structurally incomplete responses are maintained in larger proportion through the fifth year by the lower groups and seem to indicate, as has been pointed out before, the continuance of a somewhat infantile habit of speech. All of the more complex forms of the sentence are present to a greater extent in twins from the upper groups than those from the lower groups. But as in the other analyses the upper group of twins is frequently below the lower group of singletons. In the comparison of two groups, however, it must be remembered that the singletons are so grouped that the age falls three months in advance of the age of the twins.

COMPARISON OF WORD ANALYSIS: TWINS AND SINGLETONS

These data were treated in two ways. Both the total number of words used by each child and the number of different words used by each child and each age group, were separated into the parts of speech.

Figure 7 shows the percentage of each part of speech of the total words used. Nouns show close agreement for twins and singletons both in the total percentage used and in the marked drop in percentage from two to three years. The percentage of verbs in which singletons show a gradual increase, from two to four years, is relatively much less at two years in twins, equal to the singletons at three years, and constant thereafter. Adjectives increase from approximately 2 per cent at two years to 8 per cent at five years, in twins. Singletons do not show this marked increase but even at two years have 10 per cent of adjectives, which exceeds the twin five year old percentage. Adverbs, except for a slight use at three years, are constant throughout and slightly greater in percentage in twins than in singletons. Pronouns increase with age to a greater extent in twins than singletons. They are, at every age, somewhat fewer in proportion. Con junctions are late in appearing. Girl singletons show a small per cent at eighteen months and the boys show none until thirty months. A smaller per cent (.9) appears at three years in the twins, and at five years the proportion is still smaller than that for singletons. Prepositions although they show a greater increase with age in twins than in singletons, at two are much less in proportion, the same at four years, and drop some at five years. Although interjections decrease with age markedly, the twins show a very much greater proportion at all ages,

especially at two years, than do singletons. This, no doubt, is related to the large porportion of emotionally toned responses which the twins showed in the functional analysis, and like it, is somewhat indicative of maintenance of infantile language. The miscellaneous parts of speech total words used by both singletons and twins. This shows differences similar to those in the mean length of response. The singletons have but a slight advantage at two years, but show an increasing advantage with age. The 158 words attained by the twins at five years are equaled in number by

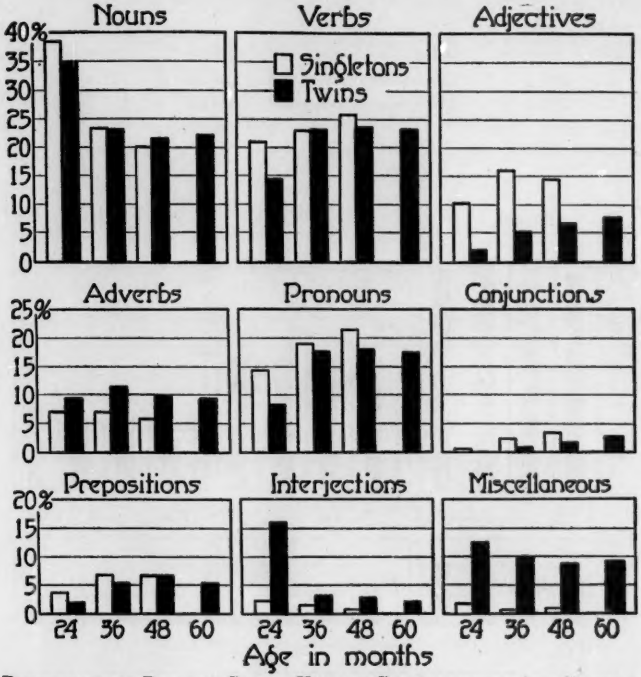

FIG. 7. PERCENTAGE OF PARTS OF SPEECH USED BY CHRONOLOGICAL AGE (BASED ON TOTAL WORDS USED)

include words which were difficult to classify more positively, such as "uhm-uh," "uh-uhm" used so frequently for "yes" and "no". These appear to be used to a considerably greater extent by twins than by singletons. This then seems to show a tendency to attain adult standards more slowly.

Table 3 shows the mean number of the singletons between thirty and thirty-six months. The retardation at five years is equivalent to approximately two years.

The percentage of different words of each part of speech used by each age group are presented in figure 8. It may be observed that the changes with age are not the same when considered

from the standpoint of percentage of different words used. For instance, the percentage of nouns remains relatively constant rather than decreasing with age. The child's vocabulary of nouns is actually increasing with age. The percentage of verbs remains relatively constant. Twins show a smaller percentage of verbs than singletons at all ages. Adjectives increase in percentage slightly with age in both groups. The percentage of adverbs

TABLE 3

Mean number of words used by C.A. and sex

CHRONOLOGICAL AGE	MEAN NUMBER OF TOTAL WORDS					
	Singletons (Mc Carthy)			Twins		
	Boy	Girl	All	Boy	Girl	All
months						
24	36.8	87.1	66.0	40.11	70.9	55.90
36	164.4	176.2	170.3	116.80	112.45	114.63
48	213.4	218.5	216.3	146.31	146.00	146.15
60				143.30	173.20	158.25

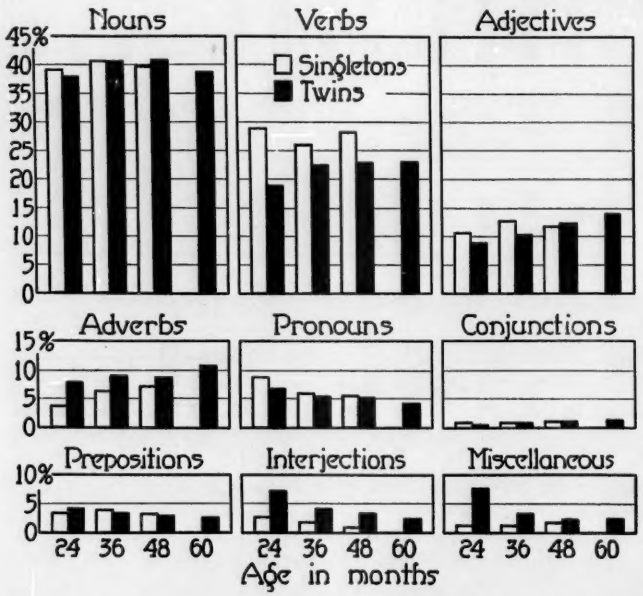

FIG. 8. PERCENTAGE OF PARTS OF SPEECH USED BY CHRONOLOGICAL AGE (BASEDON DIFFERENT WORDS USED AT EACH AGE GROUP)

increases with age more in the singleton group than in the twin group. Pronouns decrease in percentage with age although the actual number after three years remains about constant. Conjunctions increase in percentage a little in both groups and agree closely in total percentages. The percentage of prepositions decreases with age in twins and remains constant in singletons. Interjections decrease in percentage with age. The twins, however, show even at five years, a percentage almost equal to the two year old singleton. The miscellaneous words decrease with age and are higher in percentage for the twin group than for the singleton group.

The chief differences between singletons and twins in percentage of parts of speech used are in verbs, adjectives, pronouns, conjunctions and interjections. The twins differ from the singletons in showing a smaller percentage of verbs at two years, a smaller percentage of adjectives, pronouns and conjunctions at all ages, and a greater percentage of interjections at all ages. In the percentages of parts of speech of the different words, adjectives, pronouns and conjunctions do not show great differences in proportion between twins and singletons. Adverbs, interjections and verbs continue to show distinct differences. Twins show a greater percentage of adverbs and interjections and a smaller percentage of verbs.

The sex differences in percentage of parts of speech, of the total words used, are of the same order as in the singleton group although they are less in magnitude in most instances. Girls are in advance. The greatest differences appear at two years, indicating, perhaps the earlier linguistic maturity of the girls.

The total number of words used also favors the girls. As in the mean length of responses, the boy and girl twins do not differ at three and four years although they show striking differences at two and five years. In the number of different words used (table 4) girls are superior at every age except three years, when the boys exceed by 19 words, the majority of which are verbs.

The twin group when divided into the upper and lower occupational classes shows differences similar to those found in the singletons. The upper group shows a superiority which is most marked at two years in those parts of speech of greatest developmental significance. This may in-

TABLE 4

Mean number of different words used by twins and singletons

YEARS	TWINS						SINGLETONS (MC CARTHY)					
	No cases	Boys	No cases	Girls	No cases	All	No cases	Boys	No cases	Girls	No cases	All
2	19	16.4	20	24.2	39	20.4	8	16.6	12	37.3	20	29.1
3	20	45.4	20	45.1	40	45.3	10	60.1	10	66.0	20	62.8
4	19	59.1	21	56.1	40	56.5	9	91.1	11	93.8	20	92.6
5	20	61.3	20	69.4	40	65.3						

dicate an earlier linguistic maturity of twins from the upper occupational classes.

Descoeudres (2), Drever (5), Gesell and Lord (7), Hertzer and Reindorf (12), Smith and McCarthy all have obtained results which agree in showing a positive relationship between linguistic development and socio-economic status. Stern (19) in reworking the Descoeudres data estimated the difference between educated and working class children to be equivalent to about 8 months in age.

SUMMARY

1. As compared to single children twins are retarded in language development, as measured by each of the methods of analysis used.

2. This language retardation increases with age, within the age period covered (2–5 years) and is most clearly shown in the comparison of the findings of mean length of response.

3. Both in the analysis according to the structure of the sentence, and in the world analysis, twins show the greatest retardation in those phases which make the greatest change with age.

4. This is also true in the functional analysis with the exception of two phases. Ego-centric responses and dramatic imitation, which are both affected, probably by the social advantage of the twin situation, show a superior development in twins as compared with singletons.

5. A small sex difference in favor of the girls appears in all methods of analysis. These sex differences are not as great as in the case of singletons, due possibly to the operation of the social factor.

6. Twins of the upper three occupational classes are superior in all methods of analysis to the twins of the lower three occupational classes.

7. Singletons of the lower three occupational classes are superior in mean length of response to the twins of the upper three occupational classes. They are frequently superior in the phases of the other analyses.

8. The twins in this study were found to be approximately ten points below the I.Q. of the slightly superior group of singletons with whom they were compared.

If in the twin situation each child has the other for a model in speech a large proportion of the time, rather than adults or older children as in the case of singletons, perhaps we may expected slower progress with a poorer model. Nothing in the situation prevents two children from listening simultaneously to what adults say, although the time spent in practicing speech might be limited and considerably reduced. In the first place only one person can talk at a time and in the second place perhaps the activities or even the presence of a twin provide some of the satisfaction otherwise obtained from conversation. Whatever the factors may be however, the evidence is clear that during the preschool years twins progress toward adult use of language at a relatively slow rate.

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Muscular Tension as Related to Physique and Behavior[1]

ELIZABETH DUFFY

AMONG the physiological approaches to the study of temperament the measurement of involuntary tensions of the skeletal muscles has seemed especially fruitful on both empirical and theoretical grounds. It appears that studies of tension may be usefully extended in a number of directions. The present paper has as its aim, not the establishment of new facts within this field, but the suggestion of problems for further investigation. To fulfill this function it utilized certain empirical data, limited in extent, yet suggestive of relationships which would merit further study. Many of these relationships, as reported here, could well be due to chance, but where results from a number of different sources appear consistent the likelihood of chance determination is considerably diminished.

[1] We wish to express our appreciation of the assistance given us by the investigators whose names are mentioned in the body of the report and, in addition, to the many members of the staff of the Child Development Institute of Teachers College, Columbia University, who made their records and observations available. This study was conducted while the writer held the position of National Fellow in Child Development.

PROCEDURE

The data to be presented were obtained from a number of observations and measurements in the Child Development Institute of Teachers College, Columbia University. Some of the information was procured from the files of the Institute or was furnished by various members of the staff. Other information was the result of special studies conducted by various investigators who generously made their data available.

The study of muscular tension was made by the writer (3, 4) and has been described in two previous publications. Its essential feature was the measurement of the degree of pressure upon dynamographs held in each hand during discriminative reactions and during tapping. The subjects were 18 nursery school children ranging in age from 2 years, 11 months to 3 years, 10 months (median, 3 years, 3 months). Tension scores, as given in this report, represent the average of the scores from the used and the unused hand on 5 separate occasions when discriminative responses were being made. They are based on the records of 16 subjects, since 2 of the subjects failed to comply with the instructions.

The tapping records were utilized in determining the type of tracing from the point of view of smoothness. The tracings are not sharply divisible into types but may be grouped roughly into three categories: (1) very irregular, (2) moderately irregular, and (3) very smooth. The records of 17 subjects were available for this purpose.

RESULTS

Tension and weight

Of the 16 children for whom we have tension measurements, 5 are within one pound of the average weight for height and age, 6 are above the average in weight, and 5 are below the average in weight. Every one of the 5 children below the average in weight has a tension score above the median, while not a single child with a tension score in the lowest third is below the average in weight. A few children above the average in weight do, however, have high tension scores.

No assumptions need be made here as to the causal relationship between tension and weight. If it should be found, as the result of more extensive investigation, that children who are below the average in weight tend to have high tension scores, two possible explanations would be available. It might be claimed, on the one hand, that undernourished states increase the sensitivity to stimulation, with the result that the impact with the environment produces greater tension in the child who is underweight. It might be claimed, on the other hand, that habits of reaction involving great tension result in depletion of the reserves of the organism and thus reduce the weight. Probably both points of view are correct, and the reaction is of a circular nature, either factor operating as a cause of the other. It is doubtless for this reason that such conditions may become rapidly intensified until they yield only to very thoroughgoing treatment.

Tension and body build

There appears to be a slight relationship between tension and type of body build as measured by the hip width divided by the height. This measure has been used roughly, without regard to the average for the child's age and sex, but the trend of the results is in keeping with that found for weight. The rank order coefficient of correlation between tension and body build is -0.39 ± 0.13. If a line were drawn dividing the children into those above and those below the median for the group in $\frac{\text{hip width}}{\text{height}}$ index it would serve also as a dividing line for those above and those below the median in tension, with but two displacements. The trend indicated is the association of high tension with a slight rather than a heavy body build.

Tension and number of colds

The attendance records of the nursery school indicate that some of the children were at no time during the year absent because of a cold, while other children had as many as four colds during that period. Absences for colds which were not more than a week apart were taken to indicate the con-

tinuation of the original cold rather than the incidence of a new one.

There were 6 children who had at least three or four colds during the school year. Of these 6, three were among the 6 subjects who held the highest ranks in tension, while only 1 was among the 6 who held the lowest ranks in tension. The evidence is far from impressive, but, if colds are frequently the result of fatigue, it would appear likely that individuals ranking high in tension would, in general, be more susceptible to colds, since prolonged states of tension must induce fatigue.

Tension and range of systolic blood pressure and pulse rate

Records of systolic blood pressure and of pulse rate were taken by Miss Frances Baker (1). Measurements were obtained on 3 successive days at four periods of the day: from 8:30 to 9:00 a.m., when the children arrived at school; at 11:00 a.m., after the play period; at about 12:15 p.m., after lunch; and around 2:00 p.m., after the afternoon nap. The range in blood pressure and the range in pulse rate were found in each case by subtracting the lowest from the highest of the twelve measurements.

The Pearson r for tension and range in systolic blood pressure is 0.31 ± 0.14. Expressed in this form, the relationship does not appear close, but it is of interest to note that the 5 children with the highest tension scores are all *above* the median in range of blood pressure, and the 5 children with the lowest tension scores are, with one exception, below the median in range of blood pressure.

Tension and range in pulse rate yield a rank order coefficient of correlation of 0.39 ± 0.14. There were 15 children for whom both tension and pulse measurements were available. Of the 7 who were *above* the median in range of pulse rate, 5 were *above* the median in tension and, conversely, of the 7 who were *below* the median in range of pulse rate, 5 were *below* the median in tension.

The average systolic blood pressure and the average pulse rate in this group bear no relation to tension, but fluctuations in blood pressure and in pulse rate, when measurements are made at different hours and on different days, do appear to be somewhat significant.

Tension and muscular performance

A member of the staff who frequently observed the children during their play period on the roof in order to obtain data upon their muscular activity was asked to make a list of those children who showed great activity and those who tended to be inert. Four were listed in each category. The 4 showing great activity in the play group are all below the median in tension, and 3 of the 4 have tension ranks in the lowest third. The 4 showing least activity in the play group are all above the median in tension and, of these, 3 have tension scores in the highest third.

Ratings on the use of small muscle groups rather than large ones yield similar results. Two out of 3 of the children who use small muscle groups most often have tension scores in the highest third, while both of the children who use large muscle groups

most often have tension scores in the lowest third.

Success in a motor performance was also found to be related to tension. The test in the Merrill-Palmer series which requires the child to trace an irregular figure was given to 10 of these children. Of the 5 who failed it, only 1 was below the median in tension, while 3 of the 5 held ranks 1, 3, and 4 in tension.

General observation supports the conclusion that tense muscles interfere with freedom and ease of motor response and frequently, if not generally, produce awkwardness in the execution of muscular performances.

Tension and physical contacts

Miss Alice Loomis (6) recorded the physical contacts made spontaneously by the nursery school children. A full description of her method has appeared in a recent publication, from which the following is an excerpt: "Each child was observed in 15-minute periods during spontaneous activity when at least four other children were present with opportunity for social interaction, with a total of 2 hours observations on each. . . . . The observations covered 12 weeks . . . ."

There were 13 children for whom there were data on both physical contacts and tension. The rank order coefficient of correlation between tension and total number of physical contacts is -0.54 ± 0.14. The Pearson r for these data, as reported by Loomis, is -0.46 ± 0.15.

Physical contacts were of two types: accidental and intentional. Intentional contacts were defined as "the sum of aggressive and friendly contacts, that is, all physical interactions except the neutral or accidental ones." The rank order coefficient of correlation between tension and intentional contacts is -0.70 ± 0.10, while the Pearson r has been reported to be -0.73 ± 0.09. Loomis concluded that "the descriptive notes in each case confirmed the conclusion that, in this study, children with the highest muscular tension tended to avoid physical contacts though not necessarily social contact, the means being as varied as the individual."

It is of interest to note in this connection that Johnson and Wilson (5), in a study of tension during a tapping performance, reported that "analysis of the behavior of these children in social relations shows that the children with high pressure records had difficulties in adaptation." Duffy (2, 3), in an earlier study of tension, had quoted statements from nursery school records which showed that the children with highest tension were frequently "problem children," and, in a later study, has shown that "individuals with higher tension scores tended to be rated lower on stability and degree of adjustment to the environment." It was shown also that "habituation to a situation tends to decrease tension."

The sensitivity and the difficulties in adjustment in social situations which seem to characterize the "high tension" child undoubtedly deserve further investigation. Miller (7) found, in a study with adults, that, in general, an electric shock caused a smaller arm movement and was reported as less disagreeable with relaxation than without. It seems prob-

able that high tension either produces or is the result of increased sensitivity to stimulation. If this supposition is correct, it would follow that individuals with high tension might frequently react more intensely than other individuals to various types of physical and social contact. Hence, a free and easy relationship with other individuals and with the environment in general would be, for them, more difficult. It may be that from the tensions created by the impact of these individuals with their environment come many of our works of art and our polemics against existing social and economic conditions.

Tension and emotional episodes

Miss Sophie Moissides (8) observed and recorded emotional episodes which occurred during play activity from nine to ten in the morning. She included in her study all instances of laughter or crying which were visible or audible. The total observation period covered 37 hours. Since not all children were observed for an equal period of time she calculated for each child the share in emotional episodes per hour of presence.

These data correlate very negligibly with tension, the rank order coefficient of correlation being 0.24 ± 0.17. The result need not seem surprising, since individuals differ greatly in the degree to which they express emotions overtly. Share per hour in emotional episodes bears a slightly closer relationship to degree of smoothness of the tension tracing. The product moment coefficient of correlation is 0.38 ± 0.14. This aspect of the tension tracing has been held by the writer to indicate degree of inhibition and possibly, of coördination. Five of the children had a very irregular tracing and 5 a very smooth tracing. No one of the 5 with a very smooth tension tracing ranked in the highest third in emotional episodes, and no one of the 5 with a very irregular tension tracing ranked in the lowest third in emotional episodes.

Tension and number of words used

For 15 of the children there was a complete record of all the language used during a period of 12 hours. An analysis of these records provided a count of the words used by each child. The rank order coefficient of correlation between tension and number of words used is $-.37 \pm 0.14$. Four of the 5 children who are highest in tension are in the lowest third for the number of words used, but only 2 of the 5 children lowest in tension are in the highest third for the number of words used. Evidently, there is here a close association between high tension and the use of few words, but not between low tension and the use of many words. The analysis of the speech records may be taken as an index of the extent of the vocabulary, but not of the volume of speech, of the various children.

Tension and behavior during mental testing

During the mental examination the children were in relatively similar situations. It is, therefore, of interest to compare the records of the behavior of the children with the highest tension scores with those of the children with the lowest tension scores. Among the observations on the 4 children with

highest tension scores we find the following remarks:

Subject 1—The rating may be tentative as attention was fleeting throughout.

Subject 2—He appeared completely at ease and happy in the test situation. He was extremely alert, active, and exuberant. There was much extraneous activity. He was constantly shifting his chair and footstool and alternating between a sitting and standing position. He was sensitive to outside noises, such as movements in the hall.

Subject 3—She was very much at ease and happy throughout both test periods. There was spontaneous conversation, both relevant and irrelevant. She worked deliberately and accurately, but not with maximum speed.

Subject 4—He reacted to any imagined difficulty by throwing the test materials on the floor. He always picked them up pleasantly, seemed relieved by his outburst, and went on with the test.

Among the observations on the 4 children with the lowest tension scores we find the following remarks:

Subject 13—He appeared at ease and happy in the test situation. He worked deliberately and steadily.

Subject 14—She worked deliberately and with great care and precision. She seemed to be the type of child who solves problems by insight, almost never resorting to trial and error methods.

Subject 15—Her interest and persistance were marked throughout.

Subject 16—He adjusted spontaneously to the test situation. Conversation was frequent and relevant.

Three of the 4 children with the highest tension were inattentive, restless, or impulsive, while the 4 children with lowest tension were described as deliberate, persistent, or exceptionally well adjusted to the test situation. For the 4 with the lowest tension there were no remarks to indicate restlessness, emotional outbursts, or distractibility.

SUMMARY AND CONCLUSIONS

The data presented here suggest the possibility of correlations between muscular tension and various physical and physiological factors, such as weight, body build, and range of systolic blood pressure and of pulse rate. Similar correlations are suggested with various aspects of behavior, including muscular performances, number of physical contacts, number of words used, and degree of restlessness and inattention in such a situation as a mental examination.

It seems more than probable that children who habitually manifest a high degree of muscular tension are likely to have special problems which must be recognized and dealt with in a constructive fashion if they are to achieve their ultimate possibilities for poise and for generally well-coördinated behavior. Children of this type seem especially likely to be very sensitive to stimulation of all kinds. This excess sensitivity exposes them to certain dangers. It may lead to insufficiently controlled behavior of various sorts, including stammering, enuresis, impulsive emotional outbursts, and general restlessness. It may, on the other hand, be accompanied by extreme inhibition, leading to with-

drawal or lack of participation in various types of activity. In either event it increases the complexity of social adjustment. Free and easy physical and social contacts are less possible, because responsiveness is so great. The impact of the disagreeable aspects of the environment is felt more keenly, and there is need for guarding against the development of undesirable outlets for the resulting tension. Physical welfare also may suffer from the exhausting effects of too frequent excitement. But the sensitivity and the energy of response which may, under certain circumstances, be such liabilities may, under other circumstances, be valuable assets, contributing to the production of remarkable achievements of various kinds. It seems highly important that research in this field should provide us with more accurate information about the physical and behavior tendencies of the tense child, for with him guidance of reactions becomes of paramount importance.

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The Effect of Unusual Stimulation on Motor Coordination in Children

PAULINE EIGLER

THE ability of children to coördinate their reactions in response to a stimulus pattern that involves one or more unusual stimuli is a problem of learning. A study of the progress in coördination of the movements of the hand which the child can make with visual and electo-tactual stimuli recurring at regular intervals appeared to be of value in finding not only whether the child is or is not able to make the correct responses, but also in giving an analysis of the types of responses made in the attempts to learn such a problem.

In this problem are involved some factors which have been previously investigated in connection with studies on the complication experiment, simple reaction time experiment, synchronic reaction experiment, and problems involving hand-eye coördination. Because of these implications a brief historical survey will be given of this work.

In the latter part of the eighteenth century astronomers were interested in the errors of estimation made by observers. It was found that in the "eye and ear" method of fixing the instant when the star in its transit crossed the reticle of the telescope, individuals varied in their attempts to synchronize the time of the passing of the star with the beat of the clock. The differences in errors of estimation were dependent upon a factor which was termed the "personal equation." Principally from the works of Bessel, Struve, Argelander, Gill, Wolf, and Rogers (30) it was found that the nature of the object observed, its magnitude, its direction and rate of movement, and the illumination of the field were influential upon the estimates; likewise that the position of the observer, his physical condition, the habits set up by the rhythmic recurrence of the stimuli, the knowledge of the amount and direction of the errors, and the direction of attention were all factors that influenced the amount and direction of the error of estimation.

From these investigations on the personal equation there developed a type of experiment dealing with an analogous problem and termed the "complication experiment." The term was devised by Wundt to apply to the study of the temporal relation of a single impression introduced suddenly into a continuous series of impressions. The first experiment made by Wundt was one in which the reactor watched an index-hand traverse a graduated circular dial, while listening to a series of sounds which had the same rhythmic period as the revolutions of the index-hand. The subjects then attempted to judge the position

of the hand coincident with the sound. The purposes of the two types of experiments, the personal equation and the complication reaction, were analogous in that there was to be found the coincidence of the star and the meridian on the one hand, and the synchronization of the index-hand with the sound on the other. In both experiments two types of errors were made: (1) the assumed coincidence which was made prior to the actual coincidence, termed a negative error, and (2) the assumed coincidence was made later than the actual coincidence and called the positive error.

From the early studies which have been reviewed by Burrow (8) and from later studies by Dunlap (9) and Yoakum (39) the following facts were found: (1) Both rate and practice influence the amount and direction of the error; (2) The eye movements occurring with the upward and downward movement of the index-hand had a decided influence on the direction of the error; (3) The type of error made was influenced by the direction of the attention. If the visual stimulus were attended to, there occurred a preponderance of positive errors, while more negative errors occurred when attention was centered on the auditory stimulus; (4) The differences in results when the impressions were presented to one sense or to two senses were practically negligible relative to the type and number of errors; (5) Two general types of judgments were made—"spatial" and "temporal." The "spatial" judgment was that which was made when the subject perceived the spatial position of the discrete stimulus in relation to the alignment; the "temporal" was that which was made when the subject perceived the temporal relation between the two stimuli. This analysis aided in determining the type of errors made under certain conditions; (6) Types of fixation (natural, exact, pointer-pursuit) have been studied and show a direct relation to the amount and direction of the error.

The next phase of the complication problem which was studied was that of rhythmic reactions. In these experiments the subject was required to synchronize a reaction (tapping a key) to a sound or flash which was repeated regularly at several different rates. From the studies of Scripture (31, 32), Johnson (19), Mijake (22), and Dunlap (10), the results were found to be similar to those in the complication experiment. Anticipated and lagged reactions were made to both modes of stimuli. The amount and direction of the error were influenced by the rate of the stimulus and by practice. The direction of attention either to the stimulus or to the reaction had a varying influence on the type of reaction made by different individuals. The reaction to the auditory stimulus was slightly earlier than that made to the visual stimulus. Because of the brief duration of the stimuli accurate synchronization rarely occurred.

The simple reaction time experiment arose in connection with these two problems. A current definition of reaction time is "the period elapsing between the application of a 'stimulus' and the beginning of the 'action' which the stimulus initiates." The work of Cattell (12) and his coworkers and students has shown that

some of the factors and conditions which influence the reaction time are: the sense organ stimulated; the intensity, size, and duration of the stimulus; the length of the fore-period; the type of the reacting movement; practice, attention, distraction, and fatigue; incentives, punishment, drugs, and age; and individual differences themselves. The simple reaction differs essentially from the complication and synchronic reactions in that in the latter two the stimuli are recurring rhythmically and several stimulations are to be reacted to. In the simple reaction experiment only "one" reaction is made to "one" stimulus.

The complication and synchronic experiments have been made only with adults as subjects. It was one purpose of the present experiment to see what children of young ages would do in similar situations.

Ability of pre-school children in eye-hand coördinations was studied by Johnson (18), Baldwin and Stecher (3), Wellman (35), and Gesell (13). These investigators used the beat of a metronome as a recurring stimulus. Their results showed age differences. Some found sex differences aside from definite and wide individual variations. Studies of children over six years of age are those of Bryan (6), Whipple (37), Heinlein (15), Bolton (5), Bagley (2), Glenn (14), Wilson (36), and Jones (20). Again, some form of hand movement was to be made in coincidence with a recurring sound. The results for the total accuracy as well as accuracy for each stroke, although not of synchronization, showed age differentiation. Bolton and Bagley found sex differences, and Wilson and Jones found a positive relation between intelligence and the score.

For the studies on adults, aside from those previously discussed, in which synchronization was a factor, those of Bogardus (4) and Perrin (26) are notable. Both used experimental situations in which the subject was required to place a one inch cube on a designated one inch square. A block was picked up from a box with the right hand and placed on the square. It was to be removed with the left hand and placed in a funnel by which it was returned to the starting box. The blocks were to be placed at the rate of one a second. A revolving arm (one revolution a second) was so connected that its path lay over the square. If the block were not removed, the revolving arm would hit it. The square was connected electrically so that a record could be made of any displacement of the block (accuracy score). A record of the revolving arm showed the accuracy of synchronization of each placement. Both investigators found wide individual variation and a tendency toward greater inaccuracy with the use of faster rates and longer work periods.

Still another important factor which is involved in the present study is that termed "motivation" and its effect upon "learning." The problem of motivation has been of interest to experimental psychology from a fairly early stage in the development of that science to the present day. From the beginning of interest in this problem, punishment or pain has been one of the favorite modes of studying motivation. Among the forms of punishment adopted, the electric shock has prob-

ably been used more extensively than any other. The electric shock as a motivating factor in any kind of learning or behavior experiment belongs to that type of incentive to which the animal or individual reacts negatively. It has been referred to rather loosely as a "negative motivation."

The study of motivation on humans developed from investigations of animal motivation. For the most part similar problems with similar methods were studied. Electrical stimulation as a motivating factor has been used on humans in studying muscular contractions, reaction time, accuracy of movement, rate of movement, discrimination, and inhibition of response. Miller (21) studied the effect of muscular contraction and relaxation on the non-voluntary response to an electric shock. It was found that during the relaxed condition the extent of the arm movement was decreased; the reaction time of the movement was increased; and the apparent intensity or unpleasantness of the shock was diminished. Johanson (16) studied the influence of an electric shock as punishment upon reaction time. He found that the actual percentage saved in the punishment series as compared with the normal series was 14.8 per cent or 20 sigma. Rexroad (28) investigated the effect of the electric shock on accuracy of reaction to a continuous multiple choice problem. He concluded that the punishment had three effects—disruptive, incentive, and instructive. However, the resultant of the three effects in no case offset the effects from individual differences and daily fluctuations. Bunch (7) investigated the effect of a definite intensity of electric shock on adult human maze learning. She found that there was a 50 per cent reduction in the number of trials; decrease in the number of errors; and 34 per cent decrease in time per trial as a result of the intensity of shock used. Vaughn and Diserens (34) studied the comparative effects of three intensities of electrical punishment on Learning a maze. The experiment showed that light and medium intensities were most efficacious for learning as measured by errors and time. Vaughn's study (33) of the effects of positive and negative instructions in producing inhibitory behavior showed the superiority of the actual punishment (electric shock) over other motives. There were found to be large individual differences, and the children were less influenced than adults. For all the subjects the effects of negative instruction not accompanied by shock wore off rapidly. McTeer (25) investigated the effect of an electric shock as punishment in a ten-unit finger-response multiple-choice serial-order learning problem, and the effect of the shock when applied to the ankle as compared to the effect when applied to the reacting finger. The experiment showed that the punished group learned the problem with fewer trials and fewer errors than the non-punished group. Also, when the intensity was kept constant, the differences in results from differences in application were negligible. McTeer reports two unpublished studies carried out at the University of Wisconsin which investigated the effect of punishment applied to the reacting hand in maze learning as compared to the effect when punishment was applied to the non-reacting hand. One experimenter

found that punishment applied to the reacting hand was more efficacious in the learning problems. The other found practically no significant differences in the results of two groups, one with and one without shock.

PROBLEM AND APPARATUS

The specific problem of the present investigation was to study the ability to learn to synchronize a finger reaction with a recurring flash of light, and to analyze the development of this synchronization.

For this experiment an apparatus was devised so that a study could be be made of the way in which reactions were modified in development of coordination, and the effect of unusual stimuli upon this coördination.

The experiment consisted chiefly of a stimulus (a red light) flashing intermittently at a rate of once every two seconds. The duration of the flash was two-thirds of a second, and the interval between flashes was one and one-third seconds. The response to the stimulus was the depression of a reaction key. If the key were pressed when the light was on, a bell would ring; while, if the key were pressed when the light was off, the bell would not ring. An electric shock circuit was connected so that in parts of the experiment, whenever the key was pressed when the light was not on, a slight shock (.2 milliampere) would be received by the subject. This electro-tactual stimulation caused a slight pricking or tickle effect. A kymographic record was made of both the stimuli and the reactions.

This experiment was somewhat similar to other studies in which rhythmic stimuli were used in that the stimulus was responded to by the depression of a key. However, it differs in that the stimulus was not instantaneous but had a duration. This made it possible for many correct synchronic reactions to be made; whereas in reactions to stimuli of very brief duration, the exact synchronization rarely, if ever, occurs. Also, in previous synchronic experiments, work was done both with and without knowledge of the results, the knowledge being obtained from the scores or from the record after the test trial. In this experiment the ringing of the bell indicated the correctness of the response; the electric shock was also a check on the correctness of the response. Thus for each reaction, the subject knew whether or not the response was accurate.

It was found that the children liked the bell and worked to make it ring. In this way the bell acted as a positive motivation. The shock was disliked and effort was made to react so as to avoid it. In this way the shock served as a negative motivation. The experiments in which the electric shock has been used as a punishment have been those in learning and in reaction times, but the shock has never, to the author's knowledge, been used in experiments with the rhythmic stimulation. It has not been used on such young ages, although the threat of a shock has been used to inhibit movement—Vaughn (62).

The apparatus itself consisted essentially of four main units—the stimulus unit, the reaction unit, the shock unit, and the recording unit. The four units were coördinated, but for explan-

atory purposes they will be taken up separately.

The stimulus unit consisted of a synchronous motor (Dunlap model) which was used to drive four commutators arranged in pairs. The separate commutators for each pair were so constructed that either could be adjusted with respect to the other in order that the relative period during which the commutator brushes were in contact with both members of the pair of commutators could be varied over a relatively wide range. This permitted a variation in the relative amount of time the commutators were closed to the amount of time they were open for any given rate of speed. The absolute rate of the rhythmic stimulation was controlled as follows. On the shaft which carried the bank of commutators were several drive wheels of varying circumferences. The drive belt from the synchronous motor could be looped over any one of these and the speed with which the commutators revolved depended upon the size of the drive wheel used, since the speed of the synchronous motor was constant. One pair of commutators was set so that a circuit was opened and closed causing the light to flash intermittently at the rate and with the duration desired.

The reaction unit consisted of a reaction key, the button of which was insulated by a sheet of bakelite from the remainder of the key. The circuit through one recording pen remained closed, when the key was untouched, and was broken when the key was depressed; this circuit could be made and broken independent of the commutators of the control mechanism. In a second circuit, the stimulus light was connected in a series with one set of commutators. Whenever these commutators were in a position to close this circuit the light would flash. In addition to this a small electric bell was connected in series with the same set of commutators in such a way that the closing of the circuit through the reaction key would cause it to ring. Another factor in the reaction was the possibility of an electric shock. This will be explained in the following section.

Reference may be made for the construction of the electrical unit to Dunlap (21). This consists essentially of a rotary converter which was hooked directly to a D. C. lighting source. The converter thus supplied alternating current which was stepped-up by a transformer from 60 volts to about 2300 volts. This high voltage was passed through resistance which cut down the amperage to a very low and limited range. The actual amperage within a small range could be regulated by a rheostat. The current used was .2 milliampere. It was believed that using a voltage this high would practically eliminate the factor of variation in skin resistance between subjects.

The circuit from the shock-box (indicated in figure 1) was connected with the other pair of the commutators driven by the synchronous motor. From one of this pair of commutators a lead went to the wrist band which was fastened to the reactor's wrist. This wrist band was a thin piece of phosphor-bronze held in place by an elastic band. From the other commutator a lead went to the button of the reaction key. The shock was not used during

all performances of the subject; so when it was not desired, the circuit could be cut out entirely by a hand switch. The wrist band was strapped to the subject's wrist. Contact was made with the button of the key when reacting to the light stimulus. In this way the shock circuit was completed through the body, key, and wrist band.

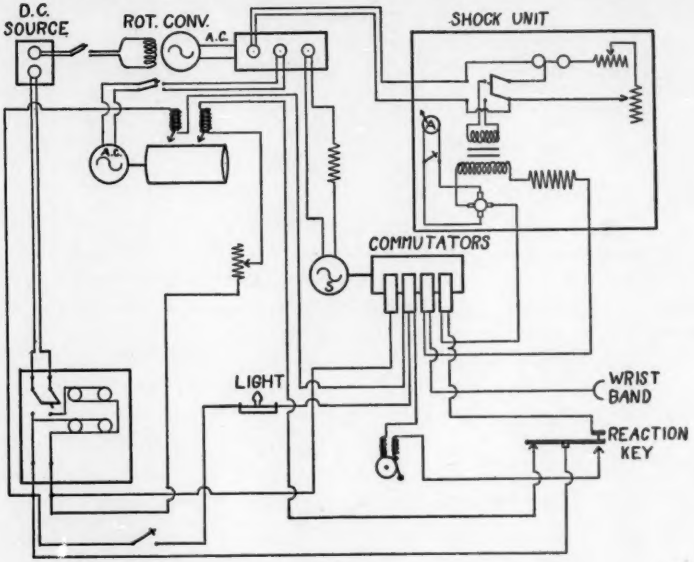

FIG. 1

When both commutators were closed, the shock circuit was shorted through the commutators, and the subject could receive no shock, whether he touched the reaction key or not. If the shock circuit were not closed through the commutators, the current would pass on down to the wrist band and to the button of the reaction key.

The last unit was a continuous paper kymograph device with two electromagnetic activated pens. One pen was connected with the pair of commutators which regulated the light stimulus. The other pen was connected with the reaction key circuit in such a way that a mark of the pen was made whenever the key was pressed, regardless of the stimulus. The two pens were set together so that the relation between the occurrence of the stimulus and the reaction could be obtained from the record.

For the coördination of these four units, the two pairs of commutators were arranged so that the stimulus circuit would be made and the shock circuit would be shorted simultaneously.

SUBJECTS

Both children and adults were used in the experiment. These may be considered as constituting the two

major groups of subjects. In the main experiment the adult group consisted of 20 persons, 9 men and 11 women. All but 4 of these were graduate students in the Psychology department of the Johns Hopkins University. Another group of 10 adults participated in a preliminary series previous to the final "learning" series. This group included 4 men and 6 women. Nine of these individuals took part in both sections of the experiment.

All of the children who took part in the experiment were members of the Johns Hopkins Child Institute. Three separate series were given with children as subjects. There were 19 children, 13 boys and 6 girls, who took part in the first series; 12 boys in the second series; 22 children, 13 boys and 9 girls in the third series. In the following table (table 1) are shown the age range and the number of children in each age group for the three series. The I. Q. range taken on the Stanford Revision of the Binet scale is also given in this table.

TABLE 1

Chronological grouping of children

First preliminary series

Group I. Chronological age range—1 yr. 11 mos. to 5 yrs. 11 mos. Intelligence quotient range—96–161.

	CHRONOLOGICAL AGE					
	Under 2 years	2–3 years	3–4 years	4–5 years	5–6 years	Total
No.	1	4	6	4	4	19
I. Q.	111	110–161	100–137	96–138	100–137	

Second preliminary series

Group II. Chronological age range—1 yr. 8 mos. to 4 yrs. 10 mos. Intelligence quotient range—107-161.

	CHRONOLOGICAL AGE					
	1–2 years	2–3 years	3–4 years	4–5 years	5–6 years	Total
No.	2	1	6	3	0	12
I. Q.	107–130	161	120–150	112–121		

Learning series

Group III. Chronological age range—2 yrs. 9 mos. to 5 yrs. 10 mos. Intelligence quotient range—89–161.

	CHRONOLOGICAL AGE					
	1–2 years	2–3 years	3–4 years	4–5 years	5–6 years	Total
No.	0	1	14	6	1	22
I. Q.		161	89–150	111–133	121	

PROCEDURE

For adults

For the preliminary tests the rate of the flash was one every second. Forty-five stimuli were given, fifteen of which were without shock and thirty were with shock. The subjects were not instructed concerning the shock until the beginning of the last fifteen of the thirty shock stimuli. At that time they were informed that a shock would be received if the key were pressed at any time when the light was off. The same subjects were given a second trial under the same conditions.

For the "learning" series the subjects were given the following written instructions at the beginning of each trial. "When you look into the black box, you will see a red light flash on and off. If the key is pressed when the light is on, a bell will ring. If the key is pressed when the light is off, the bell will not ring. Your problem is to touch the key quickly every time the light comes on, and make the bell ring. At the signal 'Ready—Go' start tapping the key with each flash of the light. Continue until the signal 'Stop' is given. Be sure to tap the key only while the light is on." Forty-five stimuli were given at a rate of one every two seconds for each trial, 15 of which were without shock and 30 of which were with shock. Ten trials were given. Knowledge of the shock was not given until the beginning of the last 15 of the 30 shock stimuli of the first trial. It was not necessary to repeat this after the first trial. Three individuals were unable to synchronize perfectly at the end of the 10 trials so additional trials were given until one perfect synchronization trial was obtained.

For children

The first preliminary test consisted of two trials. The rate of the flash was one every second and a half. Ten reactions were taken without the shock and twenty with the shock regardless of the number of stimuli required for the number of reactions.

The second preliminary test also consisted of two trials. The rate of the flash was once every second. Forty-five stimuli were presented to which the child was to react. No shock was used for these trials.

For the main test or the "learning" series ten trials were given on separate days. The rate of the flash was one every two seconds, and the duration of the flash was two-thirds of a second. It was found by the preliminary tests that a rate faster than this was too difficult for children of this age. The following instructions were given. "Let us lift up this door. Do you see the red light? Now watch it. It goes off and on, doesn't it? If we touch this button real quickly when the light is on, a bell will ring; like this"—demonstration—"Now you try it. Touch the button whenever the light is on and make the bell ring." Practice was given on touching carefully and quickly. "That's fine. Now let's put the door down; when I lift it up, you be ready to touch the button. When I say 'Go' see if you can touch the button each time the light is on and make the bell ring. Get your finger ready—'Ready—Go'—touch the button every time the light is on." Practice was

given before a record was taken for the first two trials. Forty-five stimuli were given for each trial, 15 of which were without shock and 30 with the shock. The subjects were not told of the shock until 15 stimuli had been given or unless they stopped reacting, in which case they were informed that they would get a "buzz" if they touched the key when the light was off. It was found after two or three trials that twelve children were too "afraid" of the shock to obtain satisfactory results by using it; so, the shock was not used in the remainder of the trials for those children. All other conditions remained the same.

Motivation

The experiment itself proved to be very interesting to the children, but for further motivation each child was given a cord with one colored bead on it at the end of the first trial. After each practice period the child was given one or two beads to string on his cord. All of the cords were kept in the experimental room until the end of the series, then the child was given his string of beads.

RESULTS

Before considering the results obtained in the experiment, it would be well to discuss briefly the nature and characteristics of the graphic records which were obtained of the subjects' performances and from which the quantitative measurements were secured.

By the use of electro-magnetic markers, two separate lines were drawn upon the continuous roll of record paper—a time line and a reaction line. The time line showed a deflection each time the red light flashed on and off, and at the same time gave an indication of the length of time the light was on. The reaction line varied quite independently of the time line and showed a mark each time the reaction key was depressed.

It is quite evident that the reaction marks and the time marks for any single record may stand in any relation to one another. That is, the reaction mark may show that the reaction took place during the time the light was on, or it may show that the reaction occurred at varying intervals before or after the light flashed.

In order to make use of all reactions, whether correct or incorrect, and in order to facilitate handling of the measurements, all reactions which were made were consigned to some one of four separate categories or types of reactions. These four classes of reactions were chosen and named because a predominance of responses seemed to fall into four well-defined groups and the name given to each group is typical of the spatial position of the reaction in that group with respect to the time line.

The first group was termed "synchronizing reactions" or "synchronizations." Only those reactions which were made and completed during the time the light was on were included in this group. Such a reaction can be called a movement which the subject has accurately synchronized with the recurring stimulus or red light.

A second class of possible reactions made by the subjects was the type termed "asynchronizations" or complete misses. In this group fell those

responses which were initiated and terminated during the time the red light was off. This type was a complete miss or error inasmuch as the complete movement took place between flashes and the instructions were to depress the reaction key while the red light was on.

A third type of response was that called "anticipatory reaction" or "anticipation." This type was characterized by the fact that the reaction was commenced and the key was depressed prior to the appearance of the red light, yet the reaction was completed during the flash. In other words, the beginning of the reaction anticipated the light, but a portion of the response was synchronized with the light.

A fourth and final class of responses was that in which the reaction of the subject was initiated during the period the light was on and the first part of the movement was accordingly synchronized with the stimulus, but the subject failed to complete the reaction by the time the light was extinguished. This type of reaction was designated as a "lagging reaction" or "lag" indicating that the subject delayed the final portion of his reaction.

These four types of reactions are illustrated in figure 2.

It must be mentioned that these types of movement are only characteristic of the great majority of responses. However, in some cases responses occurred which were difficult to consign to any one category. For example, a child may have kept the key depressed for a time during which any number of stimuli were presented. Such reactions did occur at times and were handled as best they could be. Another factor to be considered in the types of reactions made was the fact that quite often, especially among the younger children, the subject failed to react at all. These failures to react appeared in numbers sufficient to warrant their consideration and account will be taken of them in the results obtained.

In the discussion of the curves and tables which embody the results, the criterion of learning is taken as an increase in the number of correct responses made during the final trials

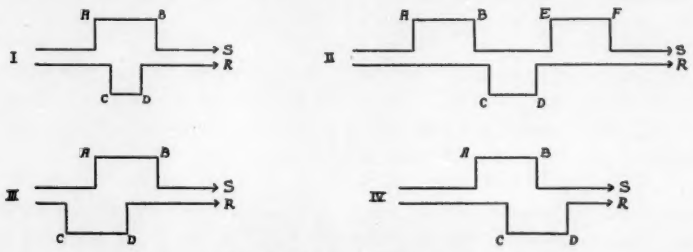

FIG. 2. TYPES OF RESPONSE

S indicates stimulus line, R indicates reaction line. AB represents the duration of the flash of light. CD represents the duration of the complete reaction. I indicates synchronized reaction; II, asynchronized reaction; III, anticipated reaction; and IV, lagged reaction.

in the series as against the number of correct responses made on the first few trials. Correct responses are those which have been classified as perfect "synchronizations" in the above discussion of types of reactions. In the curves which follow, if the line indicating the number of synchronizations shows a marked rise in level, this is taken as an indication of learning. Although this criterion of learning depends essentially upon the trend of the synchronization curve, nevertheless it is apparent that any quantitative change in the other types of reactions may throw considerable light upon the process of acquiring the correct response. The elimination of the incorrect movements is equally important in the learning process, and if it can be demonstrated that throughout the series of trials, the number of incorrect responses diminishes as the number of correct responses increases, then there is no hesitation in asserting that learning has taken place.

In the learning series the total group of children was handled throughout the experiment as a single group. Very soon after the beginning of the investigation it was noticed that the results given by the older children were characteristically different from those given by the younger children. As indicated earlier in this article, the age range of the children was from two to six years, and it is not startling that within a range this great, differing types of results were obtained. The differences between the two groups could be observed in their interest in the situation, in the difficulty with which their attention was held, and in their abilities in motor coördination. As a result of this differentiation, the number of children was considered as two separate sub-groups. But another complication appeared very soon after the introduction of the electric shock into the experimental situation. Some children of both the younger and the older groups tended to become "emotionally upset" as soon as this element was involved. Furthermore, instead of growing accustomed to the shock, some of these children grew more and more "afraid" and more difficult to handle. This antagonism to the shock continued in spite of the fact that the shock was relatively light and so arranged that it could not possibly injure the children. Accordingly, after the third or fourth trial, the shock was discontinued for those children who appeared to be too much disturbed by it. As stated previously, some of these children were members of the older group and some belonged in the younger group. The group of children was therefore divided into four sub-groups, as follows: (1) older children on whom the shock was used throughout; (2) older children with the shock removed after the initial trials; (3) younger children on whom the shock was used throughout; and (4) younger children with the shock removed after the initial trials. The older group with shock used throughout consisted of 6 boys and the older group tested without the shock consisted of 5 children, 4 girls and 1 boy. Of the younger group only 4 boys made up the group receiving the shock throughout and 7 children, 5 girls and 2 boys fell into the group which was tested throughout without the shock. A discussion of

the results of each group taken separately follows.

RESULTS OF THE GROUPS RECEIVING SHOCK THROUGHOUT THE TEN TRIALS

Younger group

In table 2 the average number of each type of response is given for each 15 stimuli presented in the first, fifth, and tenth trials. It may be noted from this table that there is an increase in the average number of synchronizations made, and a decrease in the average number of errors, the greatest reduction being in the number omitted and the next in the number anticipated. The anticipations and omissions occurred most frequently in the first trial and the lag error most frequently in the tenth trial. There were approximately four times as many correct responses made on the tenth trial as were made on the first.

In figure 3 is illustrated the proportion of the types of responses made on each trial for the ten trials. The rise in the level of the columns representing the number of synchronizations is apparent. It may also be noted that from the second trial on, the lag type of error is the predominant type of error made. For the first five trials all types of reactions were made with no one type definitely predominating, yet with a slight decrease in the number of of asynchronization and omission errors which are considered the most erroneous responses in that in neither one is any part of the reaction synchronized with the stimulus. From the sixth trial on, the synchronization type of response definitely predominates.

Learning is indicated from these facts. The process appeared to be first that all types of responses were made; second, the most erroneous responses decreased in number first; third, the partially synchronized reactions next decreased in number; fourth, a slow and then a rapid increase in the number of synchronizations was made.

TABLE 2

TYPES OF RESPONSE	TRIAL I				TRIAL V				TRIAL X			
	1	2	3	T.	1	2	3	T.	1	2	3	T.
A	3.5	0.7	0.0	4.2	3.5	3.5	3.2	10.5	7.0	7.0	6.2	20.2
B	5.0	5.5	2.5	13.0	2.7	2.5	3.5	8.7	1.7	3.0	1.7	7.4
C	4.2	2.0	3.4	9.4	5.7	2.5	2.7	11.0	4.2	1.7	3.7	9.7
D	3.5	1.5	1.5	6.5	3.5	2.0	3.0	8.5	1.7	1.5	2.5	5.7
E	0.5	5.2	6.3	12.0	0.2	4.0	3.5	8.3	1.2	2.2	1.2	4.7

Average number of each type of response for trials I, V, and X for the younger group with shock used throughout. The vertical columns numbered 1 represent the response to the first 15 stimuli presented without shock; columns numbered 2, to the second 15 stimuli accompanied by shock; columns numbered 3, to the third 15 stimuli accompanied by shock; and columns lettered T, to the total of 45 stimuli. Row A represents the average number of synchronizations; row B, anticipations; row C, lags; row D, asynchronizations; row E, omissions.

Older group

The average number of each type of response for trials one, five, and ten is given in table 3. Again the number of synchronizations increases. Each child made about twice as many correct responses on the tenth trial as he did on the first. The number of asynchronizations and omissions decreased decidedly. For this group the number of anticipation and lag errors was approximately the same at the end of the series.

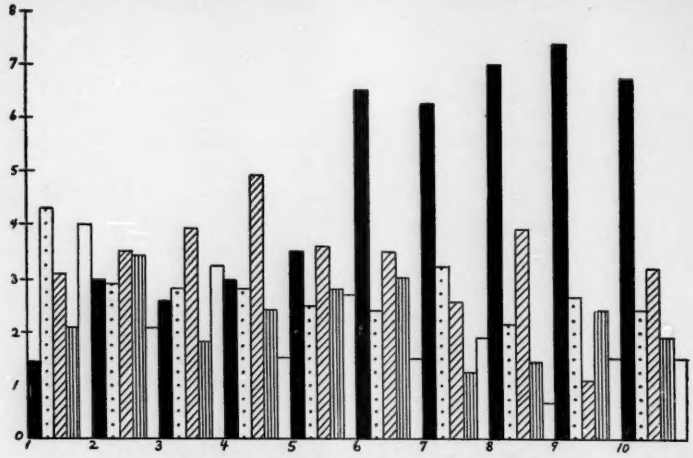

FIG. 3. YOUNGER GROUP, SHOCK USED THROUGHOUT

A group histograph in which are illustrated the types of responses on each trial for 10 trials. The successive trials are given on the abscissa; the average number of responses to 15 stimuli for the group is indicated on the ordinate. The solid column represents the synchronizations made; the dotted column, the number of anticipations; the oblique-line column, the number of lags; the vertical line column, the number of asynchronizations; and the blank column, the number of omissions.

TABLE 3

TYPES OF RESPONSE	TRIAL I				TRIAL V				TRIAL X			
	1	2	3	T.	1	2	3	T.	1	2	3	T.
A	4.5	4.6	4.3	13.5	7.5	5.1	6.5	19.1	9.3	9.0	7.8	26.1
B	1.2	2.1	1.3	4.5	1.5	1.6	0.8	3.9	2.3	2.5	2.1	6.9
C	3.3	2.5	1.6	7.5	3.5	4.0	4.8	12.3	1.6	1.6	2.6	6.0
D	2.6	4.0	3.6	10.3	1.0	1.0	1.8	3.8	0.0	0.1	0.6	0.8
E	3.8	2.1	3.8	9.8	1.5	3.1	2.5	7.1	1.5	1.5	1.8	4.8

Average number of each type of response for trials I, V, and X for the older group with shock used throughout. The vertical columns numbered 1 represent the response to the first 15 stimuli presented without shock; columns numbered 2, to the second 15 stimuli accompanied by shock; columns numbered 3, to the third 15 stimuli accompanied by shock; and columns lettered T, to the total of 45 stimuli. Row A represents the average number of synchronizations; row B, anticipations; row C, lags; row D, asynchronizations; row E, omissions.

Figure 4 illustrates the proportions of the types of responses made in each trial. The steady rises in the level of the black columns representing the number of synchronizations may be noted; also, the corresponding decrease in the number of errors. For the first three trials no one type of response appears predominately. In the fourth and fifth trials differentiation occurs in which the synchronized and lag responses predominate. From the sixth trial on further differentiation occurs in which the synchronized is definitely the predominant type. The omissions and asynchronizations are practically eliminated by the end of the series.

The same steps in the learning process seem to occur for this group as for the younger.

Adults

In table 4 are given the average number of each type of response to each 15 stimuli for the first, fifth, and tenth trials. Although the number of synchronizations on the first trial is large, yet there is an increase, and there is a decrease in all the types of errors. No omissions were made by this group. The lag type of error was the principal type of error, and it shows a marked reduction. The most erroneous reactions were made infrequently by this group; while there were quite a number of partially synchronized reactions.

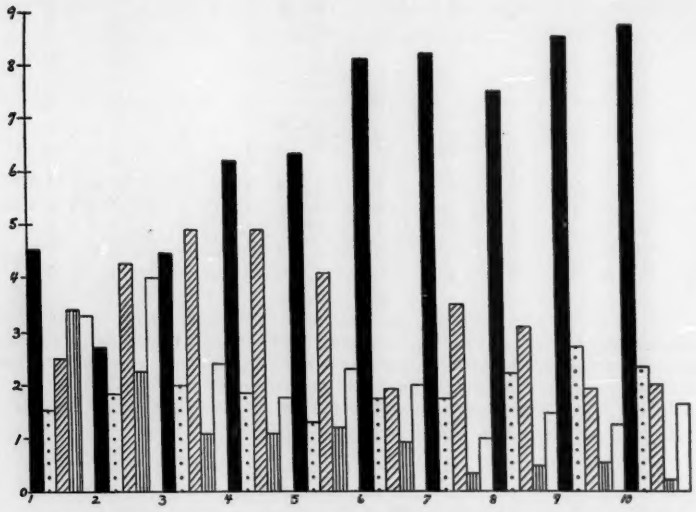

FIG. 4. OLDER GROUP, SHOCK USED THROUGHOUT

A group histograph in which are illustrated the types of responses on each trial for 10 trials. The successive trials are given on the abscissa, the average number of responses to 15 stimuli for the group is indicated on the ordinate. The solid column represents the synchronizations made; the doted column, the number of anticipations; the oblique-line column, the number of lags; the vertical line column, the number of asynchronizations; and the blank column, the number of omissions.

The results of these three groups may be contrasted and summarized as:

1. Learning occurred in all three groups as was indicated by the increase in the number of synchronizations, and the decrease in the number of all types of errors.

2. The process of the learning appeared in the two children's groups to be: (1) all types of responses with no one type predominating for the first few trials; (2) differentiation was first shown by the decrease in the number of asynchronizations and omissions made and slight increase in the number of synchronizations made; (3) further differentiation was shown by fewer asynchronizations and omissions, a decrease in anticipations and lags, and a definite increase in the number of synchronizations made. The modification in responses by adults consisted in the decrease first in the asynchronization error and then in the lag and anticipation errors.

3. The older group of children made more correct responses on the first trial than did the younger group; and further, they showed the differentiation of responses at an earlier stage. The adults made many more correct responses on the first trial than did the older group of children and their increase in correct responses began earlier than the children's. These facts, although based upon results of small groups show clearcut age differences in the ability to cope with the conditions of this problem.

TABLE 4

TYPES OF RESPONSE	TRIAL I				TRIAL V				TRIAL X			
	1	2	3	T.	1	2	3	T.	1	2	3	T.
A	13.6	13.5	13.5	40.6	13.8	14.5	14.3	42.6	15.1	14.5	14.5	44.1
B	0.1	0.1	.05	.25	.05	.05	0.1	0.2	.05	0.0	0.0	.05
C	1.2	1.3	1.4	3.9	1.1	0.4	0.2	1.7	0.2	0.4	0.5	1.1
D	.05	.05	0.0	0.1	0.0	0.0	0.0	0.0	.05	0.0	0.0	.05
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Average number of each type of response for trials I, V, and X for adults. The vertical columns numbered 1 represent the response to the first 15 stimuli presented without shock; columns numbered 2, to the second 15 stimuli accompanied by shock; columns numbered 3, to the third 15 stimuli accompanied by shock; and columns lettered T, to the total of 45 stimuli. Row A represents the average number of synchronizations; row B, anticipations; row C, lags; row D, asynchronizations; row E, omissions.

RESULTS OF GROUPS FOR WHOM THE SHOCK WAS REMOVED AT THE END OF THE FIRST FEW TRIALS

Younger group

In table 5 is given the average number of each type of response for the first, fifth, and tenth trials. It may be noted that for this group all types of responses increase in number, the number of synchronizations showing the greatest increase. Each child on the average made seven times as many correct responses on the tenth trial as he made on the first. The predominant type of response throughout

the series was that of anticipation; the least frequent response was the asychronization type. A notable failure to react. Only after the shock was removed did the children really start reacting positively to the problem.

TABLE 5

TYPES OF RESPONSE	TRIAL I				TRIAL V				TRIAL X			
	1	2	3	T.	1	2	3	T.	1	2	3	T.
A	1.0	0.5	0.1	1.6	3.0	1.1	2.3	6.4	3.1	2.5	2.1	7.7
B	4.3	2.1	1.8	8.2	5.0	5.1	4.4	14.5	4.9	5.0	6.0	15.9
C	2.1	1.4	1.4	5.0	4.0	4.0	2.2	10.2	2.6	3.5	2.3	8.5
D	2.1	0.5	0.5	3.4	1.1	1.0	1.5	3.7	1.6	1.8	1.5	5.0
E	5.5	10.1	11.1	26.8	1.8	3.4	3.8	9.1	2.8	1.6	2.8	7.3

Average number of each type of response for trials I, V, and X for the younger group with shock removed. The vertical columns numbered 1 represent the response to the first 15 stimuli; columns numbered 2, to the second 15 stimuli; columns numbered 3, to the third 15 stimuli presented; and columns lettered T, to the total of 45 stimuli. (Shock was removed after the second or third trial.) Row A represents the average number of synchronizations; row B, anticipations; row C, lags; row D, asynchronizations; row E, omissions.

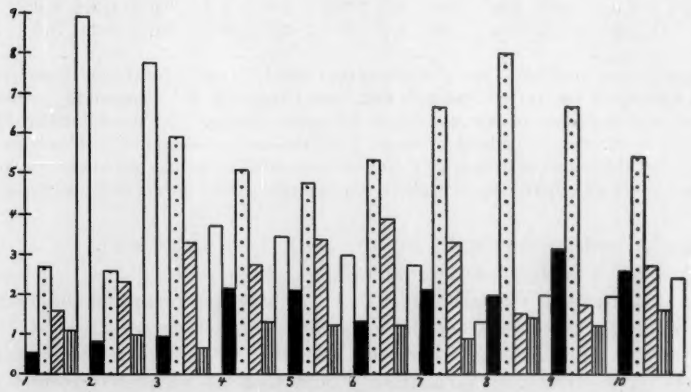

FIG. 5. YOUNGER GROUP, SHOCK REMOVED

A group histograph in which are illustrated the types of responses on each trial for 10 trials. The successive trials are given on the abscissa; the average number of responses to 15 stimuli for the group is indicated on the ordinate. The solid column represents the synchronizations made; the dotted column, the number of anticipations; the oblique line column, the number of lags; the vertical line column, the number of asynchronizations; and the blank column, the number of omissions.

fact brought out in this table is the large reduction in the number of omissions. The typical mode of behavior to the shock in this group was

These facts are shown more clearly by the graph in figure 5 which gives the types of responses for each of the ten trials. Here it is clearly seen how

as soon as the shock is removed, the level of the columns representing the number of omissions drops quite low and remains so throughout the series. For trials 3 to 7 the anticipation and lag type of reaction predominate, although there is a slight increase in the number synchronized. From the seventh trial on the anticipation type becomes outstanding and the number of syncronizations increases to some extent.

rors and correct responses, the partially correct responses constituting an intermediate stage in the process. The majority of reactors progressed by reducing the asynchronization and omission stage first, then reducing the partially incorrect responses. It may be concluded that learning has occurred in the reduction of absolutely incorrect responses, although the stage of perfect synchronization has not been reached.

TABLE 6

TYPES OF RESPONSE	TRIAL I				TRIAL V				TRIAL X			
	1	2	3	T.	1	2	3	T.	1	2	3	T.
A	1.8	1.0	0.2	3.0	4.4	2.8	1.0	8.2	1.2	2.0	2.0	5.2
B	3.8	2.0	1.4	7.2	4.0	4.4	4.8	15.2	5.5	4.2	5.0	14.7
C	2.8	1.6	1.2	5.6	2.8	1.6	3.0	7.4	4.7	4.2	4.0	12.9
D	3.0	1.0	1.0	5.0	2.0	2.6	1.8	6.4	1.5	1.2	1.0	3.7
E	3.6	9.2	11.0	23.8	2.2	4.2	4.0	10.4	2.0	2.2	3.0	7.2

Average number of each type of response for trials I, V, and X for the older group with shock removed. The vertical columns numbered 1 represent the response to the first 15 stimuli presented; columns numbered 2, to the second 15 stimuli; columns numbered 3, to the third 15 stimuli; and columns lettered T, to the total of 45 stimuli. (Shock was removed after the second or third trial.) Row A represents the average number of synchronizations; row B, anticipations; row C, lags; row D, asynchronizations; row E, omissions.

The high anticipation and lag curve rather than a high synchronization curve at the end of the series might be expected for this group, because of the fact that when making either one of these types of reactions, no warning was given and no factor was present to bring about a correction. But it might be concluded that a certain degree of learning did occur with this group in the sense that the errors of greatest extent decreased the most, and the partially correct responses increased in number. This would hold only under the assumption that a gradation exists between the absolute er-

Older group

In table 6 is presented the average number of each response for trials 1, 5, and 10. It may be noted from this table that the number of correct and partially correct responses increases, while the number of asynchronizations and omissions decreases. The anticipation type of reaction is the predominant type of reaction throughout the series. Figure 6 illustrates these facts even more clearly. The shock was removed on later trials for this group than for the younger group, but the reduction of the number of omissions

is quite noticeable. The large differentiation in response comes clearly on the eighth trial, when the anticipation type increases decidedly and all other types of errors decrease in number to a large extent.

The results of these two groups may be summarized and compared as: (1) a certain degree of learning occurred in that there was a decrease in the most erroneous types of reactions and an increase in the correct and partially correct types of response; (2) the predominant type of response was that of anticipation for both groups; (3) the typical form of behavior when the shock was used was that of failure to react.

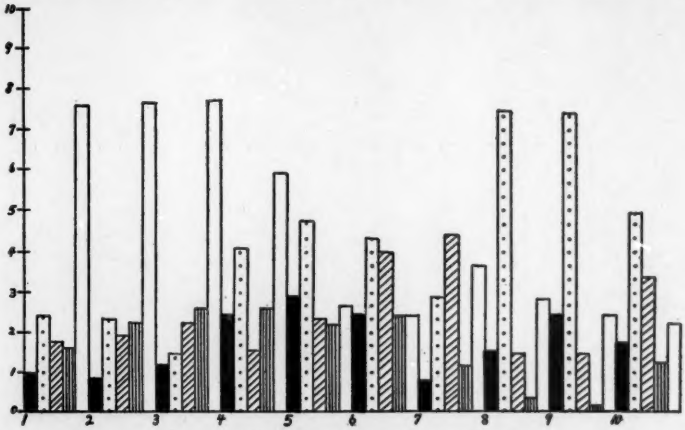

FIG. 6. OLDER GROUP, SHOCK REMOVED

A group histograph in which are illustrated the types of responses on each trial for 10 trials. The successive trials are given on the abscissa; the average number of responses to 15 stimuli for the group is indicated on the ordinate. The solid column represents the synchronizations made; the dotted column, the number of anticipations; the oblique-line column, the number of lags; the vertical line column, the number of asynchronizations; and the blank column, the number of omissions.

EFFECT OF THE SHOCK

(1) It might be said that there were two general types of response to the stimulus pattern. By one (groups receiving the shock throughout) the general attitude was to avoid the shock by paying more careful attention to each reaction, attempting to press the key at just the right time. By the other (groups having the shock removed) the general attitude was to avoid the shock by simply not reacting. This factor for the entire experiment had to be overcome before a good synchronization record could possibly be obtained.

(2) For the groups who received the shock throughout, a greater amount of learning occurred than with the group that had the shock removed. So that for the entire series it might be concluded that the shock was beneficial for the learning process. Its effectiveness was probably in its corrective value. That is, that by the shock the

subjects were aware of any error they made. However, in any one trial it was found that more synchronization reactions and fewer errors were made to the stimuli not presented with shock than to the stimuli accompanied by the shock. (The writer is cognizant of the fact that a comparison of the results of these two main groups with regard to the shock is not conclusive except for the effects as such, due to the fact that the shock was administered to all children at some time in the experiment. There was no group which learned the problem without experiencing the electric shock. It may be surmised, however, from the results found, that with such a group, the partially correct responses would predominate, because the directions would be followed and no check would be made on a slight anticipation or lag reaction.)

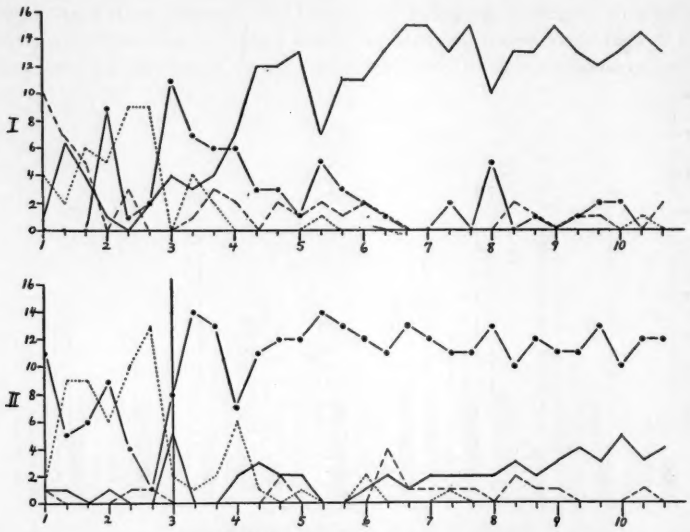

FIG. 7. SETS OF CURVES FOR TWO INDIVIDUALS IN WHICH ARE SHOWN THE TYPES OF REACTION ON EACH TRIAL FOR 10 TRIALS

The abscissa represents the successive trials; the number of responses to each 15 stimuli is indicated on the ordinate. The solid line represents the number of synchronizations made; the dot and dash line, the number of anticipations plus the number of lags; the broken line, the number of asynchronizations; and the dotted line, the number of omissions. Set I is of a child in the older group, shock used throughout; set II, child in the younger group, shock removed.

INDIVIDUAL DIFFERENCES

In each group wide individual differences were found. Figure 7 illustrates two sets of curves of individuals' responses made throughout the series. From these it may be suggested that no two individuals progressed in the same way.

SEX DIFFERENCES

(1) In the children's group no girl received the shock throughout. The girls showed much more "emotional disturbance" than did the boys.

(2) Of the group who did not receive the shock the boys had a slightly higher average of correct responses than did the girls.

(3) Of the adults, the men were slightly superior as to the number of correct responses made to the women, and the men showed an increase in the correct responses at an earlier stage than did the women.

(These sex differences are given as suggestive differences only, as conclusive statements could not be made upon the results of such small groups.)

SUMMARY AND CONCLUSIONS

The problem of learning to make rhythmic responses was studied with such instrumental control that evidence was obtained on the various stages in the learning process. The types of responses at each stage of learning showed modifications through which more accurate synchronization was established. The types of responses made fell largely into five well-defined categories;—synchronizations or correct responses, in which the complete reaction was made during the flash of light; asynchronizations or complete misses, in which the complete reaction was made when the light was off; anticipations, in which the reaction was commenced prior to the flash but was completed while the light was on; lags, in which the reaction was commenced while the light was on but was completed when the light was off; and omissions, in which case there was failure to react to a stimulus.

Twelve children were too "disturbed" by the shock to continue with the experiment unless the shock was removed. Because it was thought desirable to ascertain the reactions of these children to the problem, the shock was eliminated for this group after the third or fourth trials.

The types of responses which were elicited throughout the series by the entire group of children who received shock in each trial were: (1) no one type of response predominated in the first three trials (2) the number of synchronizations increased steadily so that in the last few trials, this type of reaction predominated; (3) of the errors made, the lag type occurred most frequently; (4) the asynchronizations and omissions were few in number by the end of the series.

The types of responses which were made in the series by the group who had the shock removed were: (1) failure to respond until the shock was removed; (2) when reactions were made during the shock trials, few were accurately synchronized; (3) for the last few trials, the anticipation type of reaction increased rapidly in number and was the predominant type of response; (4) the number of synchronizations increased slightly toward the end of the series; (5) relatively few asynchronizations and omissions were made in the last trials.

The types of response for adults were: (1) the synchronization type of reaction was predominant throughout the series; (2) the lag type of error was the most prevalent error made;

(3) some form of reaction was made to every stimulus presented.

CONCLUSIONS

1. Learning occurred for all groups. For those who received the shock throughout, the learning was more rapid and continued to a higher level than for those who did not.

2. Wide individual differences and methods of learning occurred in all groups.

3. The effects of the shock were: (a) seeming "emotional disturbance" on the part of all the girls in the children's group, and on the part of some boys; (b) of those who showed such disturbance, the typical mode of behavior was failure to react. Only after the shock was removed, was the problem attacked; (c) a greater extent of learning occurred from those who received the shock throughout than from those who did not; (d) of those who received the shock throughout, in any one trial more synchronizations were made to the stimuli when the shock was not used.

4. Age differences found were: (a) the adults began at a higher level of correct responses than did the children, and increased in the number of correct responses at a faster rate; (b) the older group of children began at a higher level than did the younger group and showed differentiation of response at an earlier stage.

5. The sex differences found were: (1) for the children, no girl received the shock for the entire series; (2) more "emotional disturbance" was manifested when the shock was used by the girls than by the boys; (3) of the group who had the shock removed, the boys synchronized on the average more times than did the girls; (4) for the adults, the men were slightly superior to the women. Fewer errors were made, and the errors were eliminated on the average at an earlier stage by the men than by the women.

(Note: The complete data for this experiment may be obtained from the doctoral dissertation on file at the Johns Hopkins University.)

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Biographical Records of Memory in Pre-School Children

E. B. Hurlock and R. Schwartz[1]

BIOGRAPHICAL records of the memory of pre-school children show how the memory of the normal child in a normal environment grows during the period from birth to six years. They also show how the latency period, or the interval which elapses between an event and the memory of it, increases with the age of the child.

To obtain the latency period, it is necessary to have not only the exact age of the child but also the length of time elapsing since the original occurrence of the experience and the memory of it. Such exact material can, as a rule, be obtained only from diaries, and even these often fail to give the necessary dates.

I. RECORDS OF MEMORY IN THE FIRST YEAR OF LIFE

References to memory during the first year of life are fewer than in later years, and many of those on record appear to be inaccurate in content, as many biographers read meanings into the child's behavior which are not justified by the facts. Dearborn (9) page 77 for example, records that a child of five months of age remembered a person over a period of eighteen weeks. This statement, judged on the basis of other records, cannot be accepted without questioning its accuracy.

Memory, during the first year, extends, as a rule, merely to impressions but lately experienced. The latency periods are brief and only gradually increase in length. The following records, taken from the works of different biographers, are arranged in sequence of age. The age of the child expressed in years and months, is put in brackets at the beginning of the quotation. The first numeral indicates the year and the second indicates the month. For example, (2;11) signifies that the child is two years and eleven months old. Where the latency period is given or could be secured it has been put in italics.

(0;3) Another child, at four months, noticed at evening the absence of his nurse, who had been gone only *a day* and cried lustily upon the discovery, looking all about the room, and crying again every time after searching in vain Preyer (24) p. 7.

(0;4) The day before the baby held up her rattle; to look at she declined to go to sleep in her mother's arms, and kept lifting her head to look at me, till I crossed the room and put myself out of sight. *Presently* she lifted her

[1] The junior writer was responsible for collecting the data used in this report; the senior writer supervised the research and helped to prepare the manuscript for publication.

head again, turned round, and searched persistently the quarter of the room toward which she had seen me disappear. Shinn (29) p. 147.

(0;5) Then he stuck his finger into his mother's laughing mouth; she bit on it; Bubi, amazed, raised his brows and looked at her as though questioning. When his mother again bit, he crowed with content, but drew back his hand. *After a brief pause*, he spontaneously stuck his finger into his mother's open mouth and looked highly expectant as he did it. Scupin (27) p. 19.

(0;5) Twenty-fourth week. He recognized his grandfather whom he had not seen for *2 weeks*. Moore (21) p. 100.

(0;6) Her nurse who had been with her continuously for five months was absent for a period of *3 weeks*, and on her return was instructed first to appear to the child simply in her usual dress but to remain silent, then to withdraw from sight and speak as she had been accustomed to; and finally to appear and sing a nursery rhyme, which by special care the little girl had not been allowed to hear during the nurse's absence. The first result was that the child gazed in a questioning way upon the face, but showed no positive signs of recognition; yet the absence of positive fear and antipathy shown at first toward the substitute nurse indicated that the visual image was not entirely strange. The tones of the nurse's voice were not at all recognized, as far as passive indications even of familiarity were concerned. The third experiment was attended by complete and demonstrative recognition. Baldwin (1) p. 316.

(0;7) 228th day. His father, whom the child had not seen for *2 weeks*, was greeted with outstretched arms while still two hundred feet away. From this time he was recognized a quarter of a block away. Hall (14) p. 465.

(0;8) A child of this age recognized her nurse *after 6 days absence* with "sobs of joy". Tracy (35) p. 48.

(0;9) Another (girl) recognized her father after a separation of *4 days*. Preyer (24) p. 7.

(0;9) 279th day. She seemed to recognize her grandmother whom she had not seen for *some weeks*. Dearborn (9) p. 114.

(0;10) Crying on going to bed in a strange room. By night the boy has accustomed himself to it.
[Note:—*from noon to night.*] Scupin (27) p. 54.

(0;10) 327th day. His uncle showed him his watch, and blowing upon it caused the cover to fly open. He then allowed the child to "blow it open". *Three days later* the boy held his father's watch to my lips, making at the same time the blowing noise plainly asking to have the cover blown open. Hall (14) p. 530.

(0;11) 338th day. Her memory for photographic portraits is now such that she remembers her numerous uncles, etc. apart, at least *a week*. Dearborn (9) p. 124.

(0;11) In the second week of the month her uncle showed her how he lifted the window-sash, and *4 days later*, catching sight of the finger handle, she tugged at it with impatient cries, trying to make the sash go up. Shinn (29) p. 244.

(0;11) A little girl recognized her nurse after *6 days absence*, immediately, "with sobs of joy". Preyer (24) p. 7.

Summary

The important characteristics of the memory of the first year of life, as recorded by baby biographers, may be summarized as follows:

1. The first signs of remembrance, although very fleeting, show themselves before the end of the first year of life.

2. During the first year, memory is, with few exceptions, strictly limited to some few people or things which the child has seen repeatedly. Mem-

ories for situations, because of their complexity, are relatively few in number.

3. Of the references to memory in the first year (only a few of which have been recorded above)

44.44% record memory for persons
37.78% record memory for objects
17.78% record memory for situations

4. In the records of memory in the first year, memory was always aroused by a sensory stimulus. Memory of this type, which is the only kind recorded at this age, is of a lower order than memory where no sensory stimulus is present.

5. The most frequent latency period is twenty-four hours and this increases towards the end of the year to five or six days.

6. Even as early as the first year of life, memory is greatly influenced by the emotional quality of the impression concerned. Painful impressions tend to leave a mark not easily wiped out.

II. RECORDS OF MEMORY IN THE SECOND YEAR OF LIFE

The records of memory during the second year are greater in number than during any of the other pre-school years. A possible explanation of this is that during the first year, the baby has neither experiences nor the capacity to remember. In addition to this, the baby has not the means, namely language, to express what he does remember. After the third and fourth years, there are so many things that the child remembers that biographers have been obliged to limit their records to exceptional cases of memory.

(1;0) The first impression of a humming fly was so lasting that the child, even after *hours* had passed, looked searchingly up and down the window in response to the question, "Where is the fly?" Scupin (27) p. 52.

(1;0) I saw no indication in the first year that she ever looked really away into the distance; but the day she was a year old she proved to know the moon, pointed out to her by someone *3 days* earlier. Shinn (31) p. 20.

(1;1) 58th week. He recognized a person whom he had seen but once, and for a few moments, *3 days* before, but by whom he had been hurt. Moore (21) p. 50.

(1;2) 426th day. *A week* after he had watched a kitty lap milk, I said to him as he drank his milk; "Albert drinks milk and kitty drinks milk," whereupon he stopped drinking and began a vigorous lapping. Hall (14) p. 525.

(1;3) 473d day. After a day in the park, where the child had seen the boys catching tadpoles in the covers of their tin pails and had seen the dog pushed into the water, he told his father with great animation; "Tadpole, water; boy, cover," and then almost crying, added, "Bow-wow, water." It was evident *two weeks* later that he still remembered the scene, as, after he had spilled some water and had been told, "Now see, your hand is all wet," repeated "all wet," then, as his face assumed a sympathetic look, he added; "Bow-wow, all wet." Hall (14) p. 526.

(1;4) The little girl M. when nearly seventeen months old received her father after only *5 days'* absence with special marks of tenderness, rushing up to him, smoothing and stroking his face and giving him all the toys in the room. Sully (34) p. 243.

(1;5) One *morning* her mother told her she was going ta-ta that evening to Somerville. When *evening* came she said, "Now mother is going ta-ta." Baby pointed out of the window to Somerville, which was just opposite,

thus indicating her comprehension. Drummond (10) p. 9.

(1;5) 75th week: A little playmate who had been away for *4 weeks* was upon his return immediately recognized. He was seen for the first time in his wonted surroundings. Moore (21) p. 102.

(1;6) On a certain evening in the latter part of the nineteenth month, I pointed out and named the moon for him. *Three evenings* later, he accidently caught sight of the moon, reached toward it and cried, "Moom." Major (20) p. 211.

(1;7) 83d week: One day, his mother, after blackening her own shoes, seated the child on a chair and blackened his. *Ten days* later he entered the room while his mother was blackening her shoes, climbed on a chair and held out his feet to have his done. Moore (21) p. 104.

(1;9) 659th day. I now showed her the difference between light and dark green. She at once grasped it, and named them correctly half a dozen times. *A week* later, I showed her the light green, and asked, "What kind of green is that?" "Light green." "And that?"—She hesitated; "Black green—no!" I gave her the word dark, and then altered the positions and asked for it, and she selected it promptly. Shinn (31) p. 52.

(1;10) On the 20th of July he came to a place of the house where he had been punished the *preceding week* because he had soiled it, and without further provocation he said at once that anyone who soiled the room gets a whipping. Tiedemann (36) p. 39.

(1;10) 98th week: He recognized at once a great variety of pictured boats, which was noteworthy, as *22 weeks* had elapsed since he had seen ocean or boat, and the pictures were unlike any which he had in the meantime looked at. Moore (21) p. 113.

(1;11) . . . . a boy manifested keen delight on again seeing his playthings after an interval of *11 weeks*. Tracy (35) p. 49.

(1;11) When he reached the station he met his cousin and called him by name, although he had not seen him for *4 months*. Hogan (16) p. 65.

Summary

1. In the second year, memory ceases to be made up of mere fleeting impressions. The latency period increases so that objects and persons are recognized even if they have not been seen for some weeks.

2. Of the records of memory in the second year (only a few representative ones have been given above);—

15.68% record memory for persons
43.24% record memory for objects
41.08% record memory for situations

3. In comparing these data relating to memory in the second year with that of the first year, the most significant fact is the great increase in memory for situations; the problem of action as contrasted with the mere sight of an object or person is coming to be an important factor in determining memory.

4. The objects remembered are of a more complex nature than those remembered during the first year. Although not very accurate and having but a short latency period, there are records of memory for colors, figures and numbers, of which there are no examples in the first year.

5. The emotional quality of the event influences the memory of it. Vividly interesting, pleasing or painful experiences are retained for a longer time than those of neutral tone.

6. In the first year, it was noted that some definite sensory experience asso-

ciated with the remembered thing was necessary to arouse the memory of it. But, the child of two years no longer needs a sensory stimulus. He has achieved the elements of adult memory, i.e., memory as a part of a train of thought, and even the factor of voluntary recall is present.

7. The most frequent latency period of the second year is two to three weeks. The longest period recorded is nine months.

III. RECORDS OF MEMORY IN THE THIRD YEAR OF LIFE

By the third year of life, memory is beginning to assume the characteristics of adult memory. The child consciously remembers things, even those of a complex nature, and mere recognition of a person or object as such is no longer significant The latency periods which have been increasing in length during the two preceding years, continue to increase during the third year.

(2;0) R.'s grandfather gave him a toy and spent the evening in showing the child how to play with it. The toy was then put away and grandpa returned home. When, after an interval of *two weeks*, the toy was again given to the child, he said, "Dahan" (grandpa). Major (20) p. 213.

(2;0) The mother of a two-year-old child had made for it out of a postal-card a sled (Schlitten) which was destroyed after a few hours, and found its way into the waste-basket. Just *4 weeks* later another postal-card comes, and it is taken from the carrier by the child and handed to the mother with the words, "Mamma, Litten!" This was in summer when there was nothing to remind the child of the sled. Soon after the same wish was expressed on receipt of a letter. Preyer (24) p. 10.

(2;1) . . . . a girl started playing creep mouse when the place and other conditions were the same as when she played *3 months* before. Kirkpatrick (18) p. 106.

(2;2) At this time the child showed that she had some color memory, for not having seen me for about *3 weeks*, she recalled that I had then been wearing a jacket with red buttons. Drummond (11) p. 60.

(2;2) During to-day's visit to his grandmother's dwelling, which the child had not visited for *almost a year*, he ran immediately to the Cuckoo-clock, and said expectantly, "Cuckoo!" Scupin (27) p. 115.

(2;3) Gunther after a holiday in the Riesen gebirge. His principal remembrance was the cowshed, as he showed by the herdboy's characteristic call beda, beda, and by crying out "hild cow." Every day he played too, puff-puff, in recollection of the railway. *Three and a half weeks* after our return we also questioned him to test the presence of definite recollections. We asked him about our host's dog, about the village children with whom ours had played, about the stable inmates, and in his simple language he could answer us on every point. Stern (33) p. 240.

(2;4) On seeing its box, the boy remembered his doll at once . . . . after an absence of *6 weeks*. Scupin (27) p. 128.

(2;4) After *6 weeks'* absence Gunther recognized his home as a matter of course. Stern (33) p. 218.

(2;5) . . . . the child went away for the the summer and did not see, or so far as I know, think of the colored cards or pictures again for a period of *6 weeks*. I then got out the cards and asked, "Where did you used to see these?" He answered at once, "Papa's oom;" that is, in papa's room. The cards were associated with that particular room. Major (20) p. 214.

(2;5) When two years and three months old, he had been staying for a month or so at a farmhouse in a little seaside village, D——, where there was a sheep dog named Bob. Some *3½ months* later he happened, during one of his walks in his London suburb, to see a sheep dog, whereupon he remarked, "Dat old Bob, I dink." Sully (34) p. 437.

(2;6) Hilde. On her return from a change lasting *6 weeks*, when we got out of the carriage before our house, she absolutely stamped with delight and said, 'Home, home.' When we got in, she ran through the rooms with unhesitating delight and surprise, recognizing everything, 'pretty table, pretty window, Hilde's cupboard,' she kept on repeating. Stern (33) p. 820.

(2;7) A girl of thirty-one months truly said that some stitches in her dress had been made by her grandma, although *2 months* had elapsed since the dress was made. Kirkpatrick (18) p. 106.

(2;8) On April 7, 1904, she picked up an archeological pamphlet, opening it at a page containing a picture of a skeleton lying in a grave She exclaimed at once: "Like zose at nuwersity!" *About a month* before, she had been taken by her father to his room in the University, where were several mounted skeletons of infants. Chamberlain (4) p. 268.

(2;8) When two years and two months old he had been staying for a month or so at a farm house in a little sea-side village D—— . . . . *Six months* after this visit, on being asked what honey was, he remarked that he had had some at D——. Sully (34) p. 438.

(2;9) . . . . child remembered, after an interval of *7 weeks* that he had seen pigs in a shed at a live-stock exhibition. Major (20) p. 214.

(2;10) Showed by his play with his doll, that he recalled having passed the night away *25 days* ago. Scupin (27) p. 182.

(2;10) . . . . a little boy when taken to Italy a second time after *4* or *5 months'* absence remembered the smallest details, e.g., how the grapes were cut, how the wine was made, and so forth. Sully (34) p. 69.

(2;11) He was impressed by the seemingly prosaic incident of an expressman's calling for his mother's baggage, and he related *8 weeks* afterwards with great color that "Man git mamma kucks (trunks)—put on wagon—know at?" Major (20) p. 215.

(2;11) Mary T——, an old playmate, who used to come regularly to play with him, came to see him a few days ago. He was so delighted to see her that he hovered over her all the time she was with him. He paid no attention whatever to me. He said to her once "I love you, Mary." He had not seen her for *a year*. Hogan (16) p. 136.

Summary

1. The data for the third year shows that, of the cases of memory selected,

11.25% record memory for persons
35.00% record memory for objects
53.75% record memory for situations

This does not mean that the child's memory is weaker for persons and objects than for situations, but it can be explained by the fact that memory for persons and objects, as such, are not recorded by the biographers after the second year unless they are particularly significant. In addition to this, the child has, by now, become very much interested in what is going on about him. Those things which interest him make a deeper impression and are remembered for a longer time than are events which did not arouse his interest.

2. In the second year, the child was just beginning to remember colors, while in the third year, memory for colors appears as a well-established fact.

3. An interesting development of the third year is the child's memory for details. The ability to repeat a verse after a period of two months, to tell a story heard the night before, and to describe in detail events which happened in the past, is an entirely new stage reached in the mental development of the child.

4. The most common latency period during this year is from one to two months in length, although latency periods of one year are frequently recorded.

IV. RECORDS OF MEMORY IN THE FOURTH, FIFTH AND SIXTH YEARS OF LIFE

Many biographies of the development of children end with the third year and consequently records of memory from the years three to six are few in number. These years are full of new and interesting experiences for the child, and while there appears to be no markedly new development in memory, impressions are deeper and more lasting than in the preceding years. It is no longer rare to find recollections of occurrences happening many months before with nothing to revive their memory in the interval.

(3;0) . . . . on being shown an engraving of his grandfather whom he had not seen for exactly *6 months*, he instantly recognized him and mentioned a whole string of events which had occurred while visiting him and which certainly had never been mentioned in the interval. Darwin (8) p. 291.

(3;1) On going to a resort in which he had been *10 months* before the boy remembers the names of the mountains Scupin (28) p. 40.

(3;2) She returned after an absence of *21 days;* and as soon as she saw the cake-box, which was broken, she said; "I'd like to mend the cake-box, will you get what's up in the bowl?" I had placed a handle and some other things in a bowl which was in a room where R. had not yet been, so she could not possibly have seen either bowl or handle. Rasmussen (25) p. 141.

(3;3) She suddenly said, without any observable cause; "E. was engaged and she cried because she had said something wrong to grandfather." The reference was to an incident with a maid who had told a lie *4 months and 18 days before.* Rasmussen (25) p. 141.

(3;4) He remembers returning from the summer resort after *61 days*, shells which he had collected there and the mother who cannot find the shells calms him by saying that she gave the shells to another child. Scupin (28) p. 37.

(3;6) When she was two and a half, Margaret spent Chritmas in Edinburgh and played a few times with a solitaire board and marbles. The following Christmas she was again in Edinburgh, and in a friend's house was shown a solitaire board and marbles. She at once came to me and began to inquire about the marbles in my house. I feel quite sure that the memory had not been vivified by any talk in the *year's* interval. Drummond (11) p. 93.

(3;7) . . . . we passed some haystacks, and R. said; "Those are what were at Miss C.'s;" but she could not have seen a haystack since she was in the country, *9 months* back, and she had neither heard haystacks spoken of nor seen pictures of them. Rasmussen (25) p. 142.

(2;9) He recognizes an old lady, whom he had seen about *a year* past, and only for the mid-day meal. Scupin (228) p. 80.

(3;11) Eva—"A zither was casually mentioned in our conversation, and the

word called forth in Eva the recollection of a incident that had occurred *five and a half months* sooner, and in great excitement she poured forth: 'Yes I know a zither; in Krummhubel there was once a blind woman and a man; the man sang and the woman played a zither. They stood by the house Villa Marie and we stood by the tower, and you, Mother, were up in the loggia listening.' Every detail was right, and the incident had never been mentioned since." Stern (33) p. 242.

(4;1) . . . . she saw a picture of a man with a scythe and said; "That's what they reap grass with;" although she had seen nothing of the sort since harvest time, *4 months* previously. Rasmussen (26) p. 53.

(4;2) Remembrance . . . . of a red dress, that had not been used for *2 years* and a definite memory-picture of the time his mother brought the dress to his bed. Scupin (28) p. 99.

(4;4) M., who was to take part in a play, powdered her hair. About *2 weeks* later L. was standing near her. He noticed some white hairs in her head; he said, "Cousin M., you haven't got all that white off your hair yet, and it grows worse. It grows right into your head." (Brown (3) p. 379.

(4;6) Our present nurse put on a blue and white striped blouse, and at once Gunther cried, "You look like Marie, Marie wore a blouse like that." As a matter of fact, a former nurse wore in the summer, when she left us, a blouse almost identical in color and cut with the other maid's. The fact had never been mentioned in the interval of *two and a quarter years*. Stern (33) p. 244.

(4;9) . . . . I showed her (R.) a nettle-butterfly sitting on a flower and said; "We saw one like that at Tisvilde (*a month* before)." R. replied, "Yes, and it's like 'the old fox.'" (i.e. 'The big fox', a picture.) Rasmussen (26) p. 56.

(5;0) Remembers, how he comes into a forest, in which he had once been *a year* ago with his grandparents, on an excursion. He remembers the details of the scene at that time. Scupin (28) p. 158.

(5;2) Remembers that Jockel, the bird, taken away *9 months* ago, played with nails. Scupin (28) p. 203.

(5;5) He met a gentleman who had been kind to him during that memorable visit to the sea-side village D—— just *three and a half years* before, and whom he had not seen since. His father asked the child whether he knew Mr. S——. He looked at him steadily, and answered "yes." Asked where he had seen him, he answered: "Down at——." He had forgotten the name of the place. On his father further asking him what he remembered about him he said: "He made me boats and sailed them in a pool." This was quite correct. So far as the father can say the fact had not been spoken of to him since the time. If this is so, it seems worth recording that a child of five and a half should recall such distinct impressions of what had occurred when he was only just two. Sully (34) p. 481.

(5;11) When Bubi saw rhubarb after a year, he attempted to remember the name, he sighed, stuck his head in his hands, and winced as if struck, then looking at the rhubarb, he said: 'Barberaba.' Scupin (28) p. 219.

Summary

1. In the biographical records of memory in the fourth, fifth and sixth years.

16.66% record memory for persons
15.00% record memory for objects
68.33% record memory for situations

Situations have become the most significant factor in determining memory in the child from three to six years of age.

2. In this period, there is a marked development in memory for complex situations and details.

3. The latency periods have also become much longer, with the most frequent periods from nine months to one year. The longest period is three and one half years, as recorded by Rasmussen (26) p. 57, and Sully (34) p. 481. Both authors record the memory of situations with many details. In the one place, the memory had pleasant, and in the other, unpleasant emotional qualities.

GENERAL CONCLUSIONS

In tracing, by the use of biographical records, the development of memory in children from birth to six years of age, the following conclusions have been reached:

1. Memory, of an impressionistic kind, appears in the first half year of life. The first instances of true remembrance appear by the end of the first year.

2. Memory, in the first year, is only aroused by a sensory stimulus, but, by the end of the second year, a sensory experience is no longer necessary to reinstate memory. It has developed into a more ideational type of experience.

3. During the first two years, memory is stronger for persons and objects than for situations. But, in the years from three to six, persons and objects *in* situations have become the significant factors in the child's memory.

4. Unusual events and things which are interesting to the child have a longer latency period than neutrally toned events. The emotional quality of the impression influences the memory of it.

5. The child recognizes and remembers colors and forms in the second half of the third year.

6. At the age of three years, the child is able after a few days to recount a story heard, and give detailed information about past experiences.

7. Even up to six years of age, the child has, according to these records, no accurate idea of time.

8. The latency period increases in length from birth to six years as follows:

[Note:—The following data give the most common periods found for these years, but not the maximum periods.]

During the first year the latency period is about five days.

During the second year the latency period is two to three weeks.

During the third year the latency period is two to three months.

From the fourth to the sixty year the latency period is one year, with a maximum of three and a half years.

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An Analysis of the Conversation of Children and Adults

MARGARET MORSE NICE

WHILE working over the results of the all day conversation of our daughter R at four years (5), I discovered that an hour's conversation could serve almost as well as the whole day's record in picturing the subject's skill in speech, since the proportions of the parts of speech of the total words were almost identical, differing only from 0.1 to 2 per cent, while the most used words were also in striking agreement. The proportions of the different words were less significant, accounting for the following percentages in the all day and hour records respectively: nouns 41.4, 30.7; verbs 27.6, 30.7; pronouns 4.3, 8.8; adjectives 12.4, 11.8; adverbs 9.5, 13.4; prepositions 2.5, 3.1; conjunctions 1.9, 0.5; interjections 0.4, 1.0.

In order to study the character and composition of speech at different ages, I recorded a thousand or more words in consecutive sentences of my daughters as follows: one example at thirty months; two at three years and one at four; two at five, one at eight, and one at ten. Finally I collected two samples from adults, one from the children's father, the other general conversation from five people in our family. Ordinary conversation in the course of household activities made up a considerable portion of all the records; the children were also occupied with play, while the adults engaged in discussions of theoretical interest during a part of the time. No subject suspected that his or her words were being taken down. Since R's first hour had consisted of 900 words, I used this same amount of conversation in the other cases. With the adults the average of the two records was taken.

These conversations give examples of the three sentence stages described in an earlier paper (6). The early sentence that averages more than one word and less than three is represented by T's record at two and a half years where her sentences averaged 2.7 words. The next three examples are of the short sentence stage, where H at three years had an average sentence length of 4.4 words, D at the same age 3.8 words and R at four 4 words. The average sentence length of the four older children were as follows: R and E at five 6.2 words each, D at eight 6.9, and E at ten 8.5. The sentences of the adults averaged 9 words.

The ages of the children in the first two stages must not be taken as typical, for each of the four was somewhat slow in learning to talk. Most children of thirty months are in the short sentence stage; at three years perhaps

half the children have passed into the established sentence stage, and only those retarded in speech have not attained it by four. E must have reached the short sentence stage somewhere around her second birthday; she was certainly well in the established sentence period at thirty-four months. D, H and T reached this stage at about the age of three and a half years. Hence, the reader must not conclude that my findings have any definite relation to age, but rather to the stage of speech development.

PARTS OF SPEECH OF THE DIFFERENT WORDS

T at the age of thirty months had a vocabulary of 318 words of which 57.8 per cent were nouns and 19.3 verbs. In the conversations she used far more nouns than any other part of speech, fewer verbs than adjectives, and very small proportions of pronouns, prepositions and conjunctions.

The percentages of the different parts of speech in the conversations of the older children are very uniform, showing in comparison to the baby a decided decrease in nouns, adjectives and exclamations; and a decided increase in verbs, pronouns, prepositions and conjunctions. The adults show somewhat more nouns and prepositions, and somewhat fewer pronouns and adjectives than the children in the established sentence stage.

TABLE 1

Percentages of the parts of speech of the different words

	EARLY SENTENCE	SHORT SENTENCE		ESTABLISHED SENTENCE		ADULT
		Range	Average	Range	Average	
Nouns	35.8	23.3–31.7	28.1	24.0–27.3	25.7	30.0
Verbs	19.2	28.0–30.6	29.6	21.0–30.2	27.2	28.7
Pronouns	3.3	9.1– 9.4	9.2	8.0– 9.7	8.7	6.9
Adjectives	20.0	12.4–14.6	13.5	13.9–19.0	16.2	13.1
Adverbs	14.2	13.4–15.2	14.2	11.3–17.9	13.9	13.1
Prepositions	1.7	3.2– 3.7	3.5	3.4– 4.3	3.9	4.4
Conjunctions	0.8	0.5– 1.8	0.9	2.3– 3.8	3.1	2.8
Interjections	5.0	1.1– 1.6	1.3	0.8– 2.0	1.1	1.1

The variety of words used increased markedly, being much the same number in each stage. The average number of times each word was used was 7.5 at 30 months; 4.9 to 4.6 at three and four; 3.2 with D and 2.8 with E at five, 2.9 with D at eight and 2.7 with E at ten, while the figure for the adults was 2.5. The small vocabulary and much repetition is reflected in the case of the baby, large vocabularies and absence of repetition in the case of the oldest subjects, while the little children were in an intermediate stage.

PARTS OF SPEECH OF THE TOTAL WORDS

In the parts of speech of the total words we find a much greater contrast between the early sentence stage

and the later stages than in the case of the different words. With the very little child nouns are of overwhelming importance, accounting for more than half of the words used, adjectives amounted to over a fifth, adverbs more than a tenth, while of pronouns, prepositions and conjunctions there was barely a trace.

If all the conversations are considered, we find nouns decreasing enormously, while verbs, pronouns, prepositions and conjunctions increase enormously. Adjectives decrease to a half, then increase slightly; adverbs increase somewhat, then drop again. In all the conversations but one from three years onward, verbs take the first place in point of numbers, with pronouns second and nouns third. The exception was H's conversation at three, where, because of her excessive use of "Mamma" which appeared in two-fifths of her sentences, nouns made up 24.6 per cent of her talk, verbs 23.5 and pronouns 18.6. In five of the eight conversations adjectives take fourth place, while in the others this is true of adverbs. The adult conversation differs little from that of the older children except in an increase in prepositions and conjunctions, and a slight decrease in pronouns.

Boyd (3) has made an exhaustive study of the development of sentence structure, having collected and analysed not only 1250 sentences of his daughter each year from the age of two to eight, but also 1800 conversational sentences from 18 English and American novelists. His daughter was precocious in talking, her average sentence length at the different ages being 3.3, 6.4, 6.9, 7.5, 7.7, 8.2, and 8.5 words. At two years her speech development was intermediate between the early and short sentence stages; from four years on the proportions of the parts of speech of her total words were remarkably stable.

TABLE 2

Percentages of the parts of speech of the total words

	EARLY SENTENCE	SHORT SENTENCE		ESTABLISHED SENTENCE		ADULT
		Range	Average	Range	Average	
Nouns	55.6	17.3–24.6	20.4	15.2–16.5	15.7	15.6
Verbs	5.9	23.1–29.6	25.4	24.7–30.7	28.1	29.3
Pronouns	1.7	18.6–23.1	21.1	19.4–24.0	21.5	18.8
Adjectives	21.3	7.6–15.0	10.6	10.2–16.5	12.7	11.8
Adverbs	11.4	13.3–18.6	15.3	10.0–13.2	11.2	11.0
Prepositions	0.5	2.5– 7.1	4.7	4.3– 8.8	6.1	9.1
Conjunctions	0.2	0.3– 1.9	1.0	2.0– 5.0	3.2	3.5
Interjections	3.4	0.5– 1.6	1.3	1.2– 2.0	1.6	0.8

In table 3 the percentages of the parts of speech of the total words are given for Prof. Boyd's daughter at eight and for the novelists whose sentence length ranged between ten and eleven words. (In the original there is one set of figures from male novelists and from another from female; in my table the two are averaged.) The results are also shown from hour con-

versations of 22 five year old pre-school children reported by Smith (8); the sentence length here averaged only 4.6 words.

The agreement of all the different tabulations is striking. Both of Prof. Again a number of words in his list of conjunctions are not so classed by the Century Dictionary. The comparatively low proportion of verbs in the novelists' conversations perhaps reflects long and involved sentences.

TABLE 3

Percentages of the parts of speech of the total words in other studies

	SMITH'S CHILDREN AT 5	BOYD' DAUGHTER AT 8	THE NOVELISTS
Nouns	15 ±5	14.6	15.7
Verbs	27 ±6	28.3	24.3
Pronouns	25 ±6	18.4	17.6
Adjectives	17 ±8	15.2	16.4
Adverbs	11 ±4	10.2	9.4
Prepositions	6 ±3	7.7	9.1
Conjunctions	2.5 ±2	5.2	6.7
Interjections	2 ±2	0.3	0.8

TABLE 4

Numbers of each part of speech in average sentence

	EARLY SENTENCE	SHORT SENTENCE	ESTABLISHED SENTENCE	ADULT
Nouns	1.5	0.83	1.1	1.6
Verbs	0.16	1.02	2.1	2.5
Pronouns	0.05	0.87	1.5	1.6
Adjectives	0.6	0.4	0.86	1.1
Adverbs	0.3	0.56	0.8	1.0
Prepositions	0.02	0.2	0.5	0.8
Conjunctions	0.01	0.04	0.2	0.4
Interjections	0.1			
Total	2.7	4.0	7.1	9.0

Boyd's lists show higher counts of adjectives and conjunctions than did my subjects. This may be due in part to a different grammatical interpretation. In an earlier paper by this author (2) possessive pronouns and nouns in apposition are classed as adjectives, whereas I considered the former pronouns, the latter nouns.

ANALYSIS OF SENTENCES IN THE CONVERSATIONS

An analysis of the make up of the early, short and established sentences as used by my children in the sample conversations and also of the sentences of the adults is shown in table 4.

The characteristic of the early sen-

tence is a preponderance of nouns, and a lack of articles, auxiliary and copulative verbs, prepositions, and conjunctions; the same is true of the short sentence to a lesser degree. The established sentence is characterized by greater definiteness and complexity as is shown by the increased use of those relational words that were largely lacking before.

THE MOST USED WORDS

Which words are most used in conversation by little children, older children and adults? Schlag (7) believes that "Those ideas that are most effective and important in the childish soul will be expressed most often in his speech;" consequently he considers the tabulating of the words that are most used by children to be of prime importance.

Upon comparing the 10 words used most often in R's whole day conversation and in one hour we find that eight are the same, while the other two in the hour fall within the second ten of the day. The ten words used most often in the four different categories are shown in table 5.

The words of the baby are vivid and important ones. The little children show egotism, desire and dependence on parents, but the older children approximate the comparatively colorless speech of the adults.

In the first list there are only two words that appear in later lists—"Mamma" in the second list and "a" in all four. Six words appear in the three later lists—"I," "you," "it," "a," "that," "to." "My" and "want" are found with both in the small and older children, while the latter have "the" and "and" in common with the adults as well as the six words just mentioned.

Six of the little children's words occur in the nine most common words of Kindergarten children collected by Horn (4), while two more are to be found in the next seven. Eight of the ten most common words of the five to ten year children are identical with the eight most common words in this list.

TABLE 5

The most used words in the 900 word conversations with the average number of times each word was used in the sample

THE 2½ YEAR OLD		THE 3 TO 4 YEAR OLDS		THE 5 TO 10 YEAR OLDS		THE ADULTS	
Mamma	238	I	68	I	53	I	34
a	75	Mamma	44	is	26	to	33
there	38	it	22	it	24	you	32
gadda*	28	this	22	the	24	the	30
Thompson†	25	my	18	to	22	is	17
away	23	want	18	you	22	that	16
ran	20	a	17	that	17	it	15
hello	18	Daddy	16	a	17	have	13
horny	18	that	16	don't	14	of	12
toad	18	to	15	and	13	a	11

* A "universal word" for all objects whose names she could not or would not say.
† A neighbor.

Eight of the little children's words occur among the 14 most common of Smith's list (8), while eight of the older children and adults fall within the first twelve.

As to the Ayres (1) list of "The Thousand Commonest Words," the baby had one in the first ten, the little children four, the older children seven with two more in the next three, and the adults seven with three more in the next six.

The baby's speech is far more individualistic than that of the older children; there is little identity in the most common words at early ages. In seven all day conversations of children from 20 to 25 months the following words appeared in more than two records: "Mamma" in 6, "baby" in 5, Daddy, "dog," "shoe," "no," in 4, "look," "more," "nose," "there" in 3.

In all but two of the nine conversations "I" is the most used word; T did not use it at all, while H at three used "Mamma" a few more times. With D at three, R at four and five and E at five, "I" was used from twice to nearly three times as often as any other word, but with the two older children and the adults the use of "I" was not much different from that of several other words—"to," "you," "is," and "the." With the exception of H, the use of "I" decreased in general from a frequency of once in every 10 words with R at four to once in every 26 with the adult. The use of "you" increased with each age from 7 with H at three to 32 with the adult; i.e. H used "you" once in every 129 words, D at three once in every 60, E at five once in every 45, D at eight once in every 39, E at ten once in every 31 and the adults once in every 28 words. Thus we see pictured the gradual development of the little egoist into a social being.

Schlag's hypothesis fits the case of the very little child, but is no longer true by the time language is well established. Schlag gives the results of two sets of data which he collected as a nucleus for his desired "Häufigskeitswörterbuch der Kindersprache." He recorded 11270 words in sentences of a six year old girl; those most used were: ich (542 times), die (416), das (405), der (270), mal (207), ist (188), da (180), hier (180), so (174), du (135), ach (129). The most common words among 12078 collected from several eight year old children were: ich (694), different forms of haben (549), der (390), die (356), das (353), da (311), ist (246), nicht (237).

The words of the older children are much less concrete and vivid than those of the little ones. Instead of nouns they learn to use pronouns, instead of gestures they employ prepositions. There is less of emotion and more of intellectual content as speech develops, and what is lost in picturesqueness is gained in clarity and in the ability to draw fine distinctions.

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Bi-lateral Transfer in the Motor Learning of Young Children and Adults[1]

ELLA L. WIEG

INTRODUCTION

THE large amount of experimentation and the vast range of discussion which have centered about the general problem of learning during the last decade indicate how rapidly interest in this field has mounted. This increased interest has not only widened the scope of problems but has stimulated interest in older and more original phases. One of the most vital and far-reaching of these problems is the effect of training on subsequent habit formation. This effect may be either positive or negative. Instances of the former are spoken of as habit transfer, and those of the latter as habit interference.

It has long been known that practice of one limb in the performance of a skilled act increases the ability of the bilaterally symmetrical part in the same act. This phenomenon has been termed cross-education.

Interest in this phase of the problem dates back to the middle of the nineteenth century when Weber (104) observed that his son, who had been taught to write with the right hand, became a spontaneous mirror writer. At the same time, Fechner (5), with whom Weber had corresponded concerning this phenomenon, made similar observations. He found that training of the limbs on one side of the body appeared to be shared by those on the other side. Simultaneously, in 1858, Volkman (20) reported an investigation in a related field. In training for tactile impressions of distance discrimination he found the idle hand sharing the gain. A more elaborate experiment, set up by Woodworth (23) in 1890, measured the accuracy of voluntary movements. He reported transfer effects from left to right and the reverse when the drawing of straight lines was practiced. He made special note of the relationship obtained between speed and accuracy. As speed increased ten-fold, errors increased six-fold.

Two years later, Bryan (2) reported similar results on an investigation in which he tested tapping ability of children at different age levels. He found crossed fatigue effects independent of body fatigue. In every instance measurable transfer from the right to the left side of the body was obtained. Further, he observed that, although in general the right hand reaction was superior to the left hand, at certain ages the left excelled.

Scripture (18), in 1894, devised an experiment to show the transfer from right hand to left hand in the ability

[1] From the Institute of Child Welfare, University of Minnesota.

to thrust a needle into a small hole. He found a 26 per cent improvement of the left hand after practicing the right hand. Davis (3), four years later completed a study in tapping in which he practiced both hands and feet. He reported definite transfer effects occurring between bi-laterally symmetrical parts, and indicated transfer to parts not symmetrical. The transfer gain was found to be greatest for the right foot, and the relative gain was greater for the feet than for the hands. For accuracy in target shooting he calculated a relative gain of .51 for the right side, and .36 for the left side, thus indicating right side superiority.

In 1900 Wissler and Richardson (22) reported large amounts of transfer for the unused hand in the use of a dynomometer, Swift (19), in 1903, found for his juggling experiments that training of the right hand was always transferred to the left. Wallin, in 1910 found the same condition to hold for the eye when training in perspective for one eye gave positive transfer effects for the other. In the same year Starch reported a mirror drawing study in which he found that during one-hundred trials of practice the idle hand improved 83 per cent in speed and accuracy, while over a fifty trial period the improvement for the idle hand was 65 per cent.

A study of transfer and retroaction, in which 4 pencil mazes were used, was carried out by Webb in 1917. He reported transfer effects in all cases, and gave special emphasis to the fact that the transfer was not uniformally great, but was a function of the first problem and of the direction of transfer.

About ten years later, in 1921, Norcross (14) attacked the problem with the specific purpose of isolating the common elements in motor learning. By practicing his subjects in inserting numbers into an adding machine, he found a correlation of +.11 between speed and accuracy, and a speed gain of 16.67 per cent by the idle hand in contrast with a 13.67 per cent improvement with practice. In the same year Lavin found in his own experiment that the subjects could, after having learned a maze pattern with one hand, reproduce its form with the other hand, and with the head as well.

Ewert (4), as recently as 1926, was the first to use a control group in the work on cross-education. Previous investigators had not taken into account the effect produced by a single trial for the hand or foot with which a transfer trial was later taken. In his mirror drawing practice Ewert found the non-preferred hand improved thirty-six per cent in time, and 21 per cent in accuracy during fifty trials. Transfer proved to be greater from the preferred to the non-preferred hand than the reverse, while the relative ability to improve was about equal for the 2 hands.

In 1928 Bray (1) examined transfer to body members not bilaterally symmetrical. He practiced skill in hitting a target seen in a mirror, and found transfer amounting to approximately six trials taking place from right hand to right foot. Less transfer occurred from right foot to right hand, but it was effective over a longer period of time. Beeby in 1930 investigated the organization of simultaneous constituents of a continuous

training skill. Both positive transfer and interference were found in the transfer from single to double-handed practice. Further, he found that the same amount of transfer occurred in the change from single to double-handed practice as from hand to hand. He concluded—". . . . that transfer is general rather than specific."

Early theories

With a single exception the studies just summarized agree to answer in the affirmative the question "Does transfer occur in motor learning?" Another question, but one showing less uniformity of opinion is that of the amount of such transfer, and the agency through which it operates. What the factors are that make transfer possible, is a question that awaits further investigation as the following review will show. The earliest workers explained the phenomenon in terms of the educational theory of formal discipline. Davis (3) spoke of ". . . . the education of attention and will power through physical training." He explained the greater degree of transfer obtained for symmetrical, and closely related parts as due to ". . . . close connection between different parts of the muscular system, through nervous means—being closer in parts related in function or position." Scripture (18) as well subscribes to the theory of formal discipline when he says ". . . . physiologically speaking, that the development of the centers govering a particular muscle causes at the same time the development of higher centers concerned with groups of muscles. Psychologically speaking, development of will power as a whole."

Current theories

As experimental evidence accumulated, the functional theory proved inadequate to account for the facts of transfer as found, and two rather distinctly opposing theories developed. One general formula—the theory of identical elements—has been proposed by Thorndike. In his Briefer Course of Educational Psychology he says ". . . . there are bonds involving situations and elements of situations which are, in the ordinary sense of the word general." These identical elements, he explains, may include specific movements, attitudes, and reactions constituting information or subject matter, or more general adjustments of an emotional, motor or mental nature. But, he says that such reactions carried over are often not consciously identified or appreciated.

In marked contrast with the followers of Thorndike stands the group that insists upon the conscious emphasis of the generalization of methods, ideals, attitudes, etc. Then there are still those who are unwilling to abide by either theory as being sufficient, but believe that both agencies must function, and that neither can stand alone in explanation. Some have expressed the belief in a spread of muscle impulse. This group feels that transfer is, to a degree at least, the result of common head, trunk, and eye movements involved, so that the apparently idle muscles are really being exercised. Davis (3) and Woodworth (23) support this view, while Wissler and Richardson (22) speak of ". . . . diffusion of motor impulses" as giving rise to transfer effects.

Swift (19) concludes that for his ball tossing experiments the conscious acquisition of method, plus the direct effect of training upon the symmetrical portions of the nervous system explains the results obtained. On the other hand, to quote Webb—"Rational elements are present in humans, but it is recognized that these ideational activities function with little effectiveness in the mastery of the problem."

Norcross (14), who attempted to single out identical elements concludes that (1) general habits and conditions improve; (2) emotional set is perhaps somewhat of a factor; (3) higher centers are concerned. Lavin (54) feels that his own study shows that muscle joints, and tendon sensations, and sensations of cutaneous origin were factors. But, he states, that some spatial scheme was developed, and expressed in terms other than through local motor sensations, was equally apparent. He found, for instance, that watching others make the movement was more effective as a method of teaching than the mere performance of the act by the subject.

Pear (16), in his discussion of "The Nature of Skill" differentiates between "intension" and "extension." He says "Altho transfer resulting from, and merely due to exercise of any particular function . . . . ." is rare, he believes that transfer ". . . . resulting from extension of attitudes, sentiments, ideals and knowledge of methods . . . ." can occur. In referring to the conclusions of Langdon and Yates (10) he says that since low grade skills require minimal attention, transfer ". . . . might not be expected between this 'insulated entity' and the rest of the personality."

Similarly Bray says "The explanation lies, in part at least, in transfer of methods, which having been learned for one part of the body, are carried over to practice with another part. More familiarity of setting is also probably important." Beeby, in his report speaks of the subjects as saying they "let the arm swim," and he therefore concludes that, although the focality of consciousness is the essence of the "learning stage," later practice is best in a ". . . . vague, uniform, even slightly dazed state of mind."

Scott, working with the stylus maze also recorded subjective reactions. He found his subjects unaware of the reason for doing a thing. They expressed the feeling as a motor "impulse to go—thus causing the pattern to function non-consciously." Even when only a few errors were made his subjects often failed to recognize the pattern. Further, he states that recognition usually came suddenly. This finding is in harmony with Wheeler's statement when he says "Transfer is not dependent upon common elements, for there are no common elements from the standpoint of organismic physiology. Rather, it is a case of falling under the third organic principle, namely, the whole governs the activities of its parts."

McGeoch and Oberschlap, who find an increase in the ease of learning the six-and-twelve-letter problem as a result of practice at one another, and at the eighteen-letter-problem conclude —"Transfer to the eighteen-letter problem does not occur consistently.

A possible explanation of the latter fact is that transfer is a function of the amount of the preceding practice, measured in actual learning effort. On this assumption one would expect less transfer from the shorter to the longer problems."

This review indicates rather clearly that, despite the long continued investigation, the problem of cross-education is in need of more research. The present study was undertaken with the hope of throwing further light on the existing theories of transfer; first, by means of measuring the transfer effects for hands and feet in the serial motor learning of young children; and second, by comparing this performance with the performance of adults on the same learning problem. By throwing into relief the cumulative effects of the relatively long period of general practice enjoyed by adults, such comparative data should indicate whether transfer is determined by specific or general training.

Aside from serving these more immediate aims, data of this study lend themselves readily to an analysis of error elimination, since the maze used presented homogeneous units in all respects except that of the relative direction of culs-de-sac.

METHOD

Subjects

A total of 44 children, 24 boys and 20 girls were used in the experiment. Ages ranged from sixty-six months to seventy-eight months. The children were obtained from the first grade of a parochial school; first grade and kindergarten of a city school; and the kindergarten of the Institute of Child Welfare; all in the city of Minneapolis. In addition to the 44 children, 17 adult subjects were used. These were drawn from the graduate students and clerical staff of the Institute of Child Welfare.

A single group of cases provided both the experimental and the control subjects. To accomplish this, the total number of children was grouped in "sets" of fours, so as to obtain, as nearly as was possible, an equated "set" made up of a right hand, a left hand, a right foot and a left foot learner. Thus each subject was given a three fold matched control. Matching was based on I. Q., C. A., socio-economic status, sex, and maze learning ability. No effort was made to equate adult groups.

"Sets" were kept approximately within a range of 20 points in I. Q., 3 months in C. A.; 3 occupational classes (based on the Minnesota Scale); same sex; and matched as closely as was possible in maze learning ability.

Apparatus

The lack of an instrument for serial learning suitable for both hand and foot action made the development of new apparatus necessary. In devising this, several essentials were kept in mind.

(1) To reduce the time element to the lowest possible limits since experimentation in learning with young children is difficult at best.

(2) To make the problem sufficiently difficult so as to provide differentiating possibilities.

(3) To reduce intrinsic variations of the problem to a minimum.

(4) To obtain an instrument showing acceptably high reliability.

(5) To provide an apparatus making possible a comparative study of child and adult.

Husband's (9) work, which supported the conclusions of Miles (13) and Nyswander (15) by demonstrating that his subjects took 16.7 trials to learn the same pattern in the high relief finger maze that took Warden's (21) subjects 69.4 trials with the stylus maze, suggested that a maze affording cutaneous contact would best satisfy essential No. 1. The T type of cul-de-sac, shown by Nyswander and Stone (15) to give satisfactory reliability, was selected.

To insure higher reliability adaptation trials were given on a maze constructed of similar materials, but very different in pattern.

Unity of the problem was maintained to the greatest possible degree by using a single type of cul-de-sac; making all connecting paths of equal length; following every true path with an equal length of cul-de-sac; and making the two bi-lateral halves comparable in the number of culs-de-sac used—thus giving the same number of culs-de-sac on each side of the midline of the body.

Since by preliminary experimentation the standard type of blindfold—described by Miles (13) and others—was found disconcerting for both children and adults, the screen method was used instead.

Figure 1 shows the mazes used. The rounded grooved paths were constructed from sheet metal having soldered mitre joints at the turns. The total pattern was then soldered to a wood base, one inch thick, covered with sheet metal. The finger grooves, one-half inch wide, and about one-quarter inch deep, had a main arm of the T two inches long, a cross bar two inches long, whereas all connecting paths were four inches long. Thus every true path was followed by a cul-de-sac of equal length.

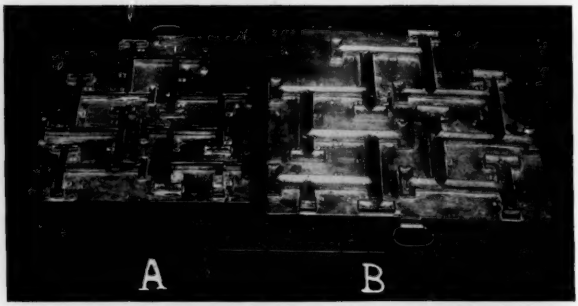

FIG. 1

Only forward-going culs-de-sac were used. Since the length of path units was kept uniform, and the same avoidance reaction pattern was presented by each blind, the mazes provided, theoretically speaking, perfect homogeneity.

Procedure

For adaptation trials all subjects were given 3 successive trials with each hand and each foot, for two days.

For finger learning the maze was placed on an ordinary card table with the cloth screen shown in figure 3 covering it. The cloth was mounted on a metal frame 18 inches square and 11 inches high.

Figure 2 shows the same from the experimenter's position. Figure 4 shows a revolving chair, adjustable to the height of the individual child. For foot learning the toe maze was placed on the floor, directly under the table, a cloth cover remaining over the pattern until practice began.

Three successive practice trials were given daily until the subject satisfied the criterion for "complete learning," which was defined to mean not more than two errors in three successive trials. To avoid the possibility of over-fatigue and impatience, no more than ten minutes were allowed for each trial, and if the goal was not reached within this ten minute period the trial was called a failure. Six of the 54 initial trials proved failures. In the early stages toe learners frequently, and finger learners occasionally, showed symptoms of fatigue long before the ten minute period expired. To overcome this the subject was given a relaxation period whenever the re-

FIG. 2

FIG. 3

quest was made; sometimes the rest had to be suggested by the experimenter as fatigue became evident.

The problem of proper motivation was considered to be one of vital importance. An attempt to keep this uniform for the whole experiment proved futile because the motivating power of an incentive varied greatly from group to group. While the subjects from one school worked zealously for score improvement in anticipation of carrying away with them a Dennison seal, those from the other schools considered this as somewhat of an insult. Since interest and effort of the subjects were of vital importance, the incentives were selected to meet the needs of each group.

Rewards—if such they may be called—were given regardless of the degree of success or failure; effort rather than score was applauded. The major portion of the directions was given when the adaptation trials were taken. The subject was seated before the maze and, being shown a sample piece (composed of a true path and a T), was given the following directions:

"This game is played by running the fingers in a path like this. The path under this cover is long and has many turns like a road. The trick is to find the sand paper post at the end of the road. The road begins here (finger placed on the beginning post), and at the end is another post like this, but covered with sandpaper. Some turns in the road take you the right way, and some take you the wrong way. Some take you to an end like this. When you come to an end, you must back up, and find a road that takes you where you want to go. (Subject was asked to run the finger in the sample groove). Do you feel how the

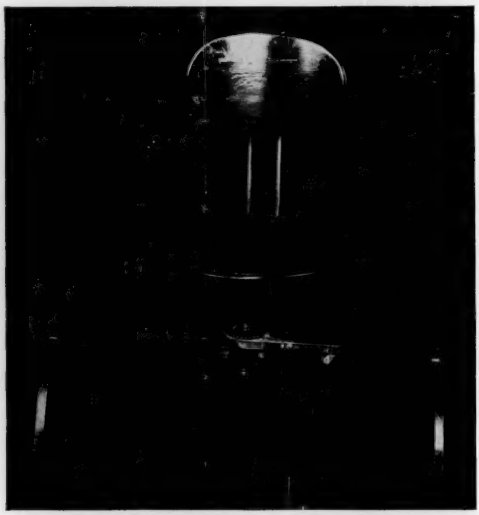

FIG. 4

turns sometimes come on one side of the road and sometimes on the other? Then you must be sure to feel both sides with your fingers. When your hand gets tired we will rest. When I say 'Ready, go' you start your finger to find the sandpaper. You may go just as fast as you like, but be sure to go carefully so you feel both sides of the path."

The index finger was placed on the starting point, and the other fingers were curled under so as to discourage the exploration of the paths in the adjoining section. When the toe trials were begun, the following directions were added: "Your big toe is going to do just what your finger did. Try it on this little piece. Be sure to feel both sides of the path."

When learning proper was begun the following directions were added: "This is a new game. It has a road just like the other game; but the road has many more turns. You'll find a sandpaper post at the end." For finger learning, a sample of the narrow path was presented, and the subject was allowed to run the finger along the groove.

In the early stages three-minute relaxation periods were allowed between trials. Later, the subject decided for himself the time needed for rest. Although conversation was discouraged, three "stock" phrases were used to assure attention when there was evidence of "wandering." These phrases were:

(1) "Your finger (toe) knows just how to go along this road."

(2) "You have a fine finger (toe): it feels both sides of the path."

(3) "You are always thinking about finding the sandpaper, aren't you?"

Running records were taken of the finger and toe reactions. All true paths were lettered, the main arms of the T were numbered and the two halves of the bar of the T culs-de-sac were recorded in symbols. Time for each trial was recorded by means of a stop watch.

Each set of 4 equated subjects composed a unit which remained constant both for learning and for transfer measures. Subject No. 1 of each set learned with the right hand; subject No. 2 with the left hand; subject No. 3 with the right foot; and subject No. 4 with the left foot. Five of the ten sets learned the true pattern, and five sets learned its mirror image. By matching the subjects in each set (on the basis of the criteria mentioned on page 251) it was possible to get control scores for hands and feet (hereafter spoken of as "members") within the experimental group. The mean of initial trial scores for each hand and foot gave the control score from which transfer was measured. This eliminated the troublesome problem of evaluating the differences in adjustment between the control and the experimental subjects. It also afforded for every learning member a control measure when the toe or finger had no subsequent trial.

In obtaining transfer measures, as many variations were used as the small number of subjects permitted.

(1) Transfer from one pattern to its opposite (making two variations).

(2) Bi-lateral transfer (hand to hand or foot to foot).

(3) Transfer to the same side of the body (hand to foot or foot to hand).

This afforded five sets for each of the four transfer variations.

With the adult subjects an additional variation was introduced, a measure of "diagonal relationships" (right hand to left foot) being obtained. The RH to RF as well as the RF to LF direction was omitted.

reliability of the combined scores for all members and for both patterns was computed, the Pearson Product Moment formula being used in this instance. In the case of the adults, only the combined scores were used, since the number of cases was so small. Here the number of trials had to be limited to 6 because hand learning was completed in 2 days by one subject.

TABLE 1

Odd-even reliability based on time and error scores

(a) Children and (b) Adults

TRIALS	MEMBER	NUMBER	RANK ORDER "Stepped up"	
			Time	Error
(a) Children				
4–9	RH	11	.94	.96
4–9	LH	11	.97	.88
4–9	RF	11	.89	.62
4–9	LF	11	.72	.66
			True pattern	
4–9	All	22	.96	96
1–8	All	19	.98	.96
			Mirror image	
4–9	All	22	.96	.91
1–8	All	18	.96	.93
(b) Adults				
1–6	All	17	.96	.84

Reliability

Reliability coefficients were computed, for time and error scores, by the odd-even method on 44 children and 17 adults.

Spearman rank order coefficients were obtained for each hand and each foot separately, and again for each pattern separately. In these cases the "Spearman-Brown Prophecy formula" was applied. In addition, the

Table 1 gives the results for children and adults for both time and error scores.

Reliability is found to be higher for hands, when compared with feet, on both time and error scores. No definite superiority for either side of the body is indicated by this table. When reliability for time is compared with

that for error, time is found a more reliable measure for three members, while the RH shows slightly higher reliability for error scores.

These coefficients are rather higher than those commonly obtained for maze learning. Two possible explanations are suggested. First, in the construction of the instrument, every possible effort was made to incorporate elements which have by previous experimentation proved to yield high reliability. Here are included the T type of cul-de-sac used by Stone and the idea of cutaneous contact developed by Miles (9) and Husband. Second, 2 days of adaptation trials were provided. This unquestionably aided in better adjustment to the situation as a whole when practice began, and tended to make performance on the real problem more stable.

TABLE 2

Means and range based on initial error scores for 40 children and 17 adults; also the percentage ratio between the scores of children and adults

		MEAN NUMBER OF ERRORS	VARIABILITY		RATIO CHILD / ADULT
			Range	C of V	
RH	Children	36.2	61	53.81	.49
	Adults	73.6	101	56.25	
LH	Children	23.1	53	69.27	.84
	Adults	28.5	85	103.57	
RF	Children	29.4	38	37.65	.44
	Adults	66.8	168	27.97	
LF	Children	30.1	36	44.18	.54
	Adults	56.0	120	110.02	

RESULTS

Learning

Initial records for accuracy show children making the smallest mean number of errors with the left hand, and the largest number with the right hand. (See table 2.) The two feet show practically like degrees of accuracy, and take positions between the two extremes of the hands. The same statements hold for adults.

Adults make more mean initial errors than do children with each of the four learning members. Adults show greater range than children for all body members, and greater relative variability for the RH, the LH, and the LF. Comparison of the limb-to-limb performance of the two age groups shows children with the smaller variation from hand to hand. The left hands of the two groups tend to approximate each other more closely than do any other two limbs.

Comparison of adults and children

For initial speed as measured in inches traveled per second of time adults obtain higher scores than children for each of the four learning members. The data are presented in

table 3. Adults make the greatest speed with the RH, whereas children show the greatest speed with the LH. For adults the LF is superior to the RF, and for children the reverse is true. This shows for both age groups the cross-relationships; the order from highest to lowest mean initial speed for children is LH, RH, RF, LF. For adults the order runs: RH, LH, LF, RF.

Both age groups show the LH to be most variable in its performance. Initial speed records show children with greater absolute variability than adults for all members except the LH. Adults show the greatest divergence between performances of the RH and RF, whereas children show the largest difference between scores for the LH and the LF.

For both age groups, performances of RH and LH show greatest similarity. The scores for RF and LF come second in order of likeness while the comparison between the performance of hands and feet shows the greatest dissimilarity for both children and adults.

Comparison of speed and accuracy

Comparison of speed and accuracy records within each age group shows children with the best speed and accuracy record for the LH, and the second best speed and poorest accuracy record for the RH. Adults made the best speed and the poorest accuracy record with the RH, and the second best speed and the best accuracy record with the left hand. For both groups the foot of greater speed is the more accurate. Thus an inverse relationship between speed and accuracy is obtained for the RH.

Practice effects

Practice carried out to meet the criterion set for complete learning, shows different effects for the four limbs and for the two age groups. (See table 4.) Certain effects, however, are constant for both age groups. Absolute variability increases with practice for children and adults alike. Both groups show the RF with the largest percentage increase over initial speed score, and both groups show the difference between RH and LH final speed scores to be the smallest when a limb-to-limb comparison is made. Both groups take the order of LH, RH, RF, LF when members are ranked in order from the highest to the lowest final speed scores. (This is the order held by children on initial status also.)

TABLE 3

Means, S.D.'s, σ M, and range for initial speed scores of 40 children and 17 adults

	M		S.D.		σM		RANGE	
	Child	Adult	Child	Adult	Child	Adult	Child	Adult
RH	.567	1.175	.15	.07	.05	.07	.51	.20
LH	.720	.998	.23	.21	.07	.21	.86	1.54
RF	.364	.573	.13	.09	.04	.09	.50	.49
LF	.327	.771	.15	.08	.05	.08	.50	.30

Practice shows differentiating effects for the two groups and for hands and feet in several instances. Adults, who showed the lesser absolute variability on initial status, are more variable (absolute) than children on final trials. Adults have also become more variable relatively for the RH, LH, and RF, while children remain more variable (relative) with the LF.

Adults show larger mean final speed scores than children for both hands and feet. Both groups show the RF making the greatest progress through practice. Adults show the smallest advantage over initial speed scores with the RH, and children with the LH. (The hand of greatest initial speed showing the smallest percentage of advantage for both groups.) The capacity for gain (measured in terms of percentage of advantage over initial scores) is more uniform for adults than for children when a limb-to-limb comparison is made.

Trials taken for learning

The number of trials taken for complete learning—in other words the effect of practice upon accuracy—again shows differences in efficiency between the groups and also between hands and feet. For children a ranking of limbs on the basis of the number of initial errors made results in the order of: LH, RF, LF, RH. When limbs are ranked on the basis of the number of trials taken, the order is: LH, RH, RF, LF. When ranking is based on the relative progress made in accuracy, the order is: RH, LH, RF, LF.

This indicates that for children hands have greater capacity for gain than do feet, and that the right side gains more than the left side.

For adults the ranking of limbs on the basis of initial errors yields the following order: LH, LF, RF, RH. Ranked on the basis of the number of trials taken for learning gives the order

TABLE 4

Data for initial speed, final speed, absolute gain, percentage ratios, absolute and relative variability for 40 children, and 17 adults

		SPEED		GAIN		VARIABILITY			
		Initial	Final	Absolute	Per cent ratio	Absolute		C of V	
						Initial	Final	Initial	Final
RH	Children	0.577	1.831	1.27	322.9	0.51	1.01	26.1	19.6
	Adults	1.175	2.891	1.72	246.0	0.20	1.21	5.9	29.4
LH	Children	0.720	1.965	1.25	272.9	0.86	0.93	31.6	18.3
	Adults	0.995	3.026	2.05	305.2	1.54	2.77	21.0	30.0
RF	Children	0.364	1.551	1.19	426.0	0.50	0.70	36.5	14.8
	Adults	0.573	2.231	1.66	389.1	0.49	2.19	15.7	33.1
LF	Children	0.337	0.938	0.61	286.8	0.50	0.88	45.2	39.4
	Adults	0.771	2.01	1.24	260.7	0.30	1.31	10.3	26.3

of: RH, LH, LF, RF. Ranked on the basis of relative progress made in accuracy shows the order of: LH, LF, RF, RH. In terms of capacity for gain in accuracy, this indicates a left side superiority with the hands taking the extreme positions. For adults, the number of initial errors appears to parallel the capacity for improvement in accuracy, but for children no such relationship is apparent.

Adults show greater limb-to-limb variation for capacity to improve in accuracy than do children.

A comparison of the two age groups for the four learning measures used, namely: initial speed, initial error, final speed, and the number of trials taken for learning, shows the two groups most nearly alike in initial speed, and most widely different in the number of trials taken for learning. Since adults made more initial errors than children, this difference in capacity for improvement in accuracy becomes even more striking.

Transfer

The speed and error scores for transfer are given in table 5. Transfer speed scores show for children positive effects for seven of the directions used, and negative effects for one. For accuracy the initial error scores are reduced for six of the directions used, and increased for two. For both speed and accuracy the poorest transfer scores are made for the H-to-F directions.

Adults show positive transfer effects for both speed and accuracy for each of the eight directions used. They show the best speed transfer scores when going from a RH learning to a LH transfer trial, whereas children show their best mean score for the RF to RH direction. (In each case the hand of greatest initial speed obtained the best transfer speed score.)

Adults show the poorest mean score for the LH to LF direction, and children make lowest score for the RH to RF direction. (In each case the lowest transfer score was obtained when the hand of highest initial speed was placed in the *learning* position.)

For both age groups transfer results for speed are always better when going in the direction from the less efficient to the more efficient limb (efficiency being based on initial and final speed scores). For accuracy the same tendency is shown—transfer scores showing the higher accuracy when going

TABLE 5

Mean transfer scores for children and adults based on mean speed and error scores

LEARNING LIMB	TRANSER LIMB	CHILDREN		ADULTS	
		Speed	Errors	Speed	Errors
RH	LH	0.96	5.2	2.77	0.0
LH	RH	1.25	2.71	2.54	0.67
LH	LF	0.35	37.0	0.57	2.0
RF	LF	0.55	6.16	1.73	0.0
RF	RH	1.43	5.25	2.11	1.0
LF	LH	0.99	0.5	2.07	0.0

from the less accurate to the more accurate member (as based on initial error scores). When learning members are held constant, and transfer members vary, the better transfer score is obtained for the member showing greater efficiency on initial status. When transfer members are held constant, and learning members vary, the better effect is obtained for the learning member having the smaller initial speed score.

For the H-to-H transfer both groups show the better score when the hand of better initial speed is in the transfer position. For bi-lateral foot transfer both groups show the better effect when going from RF learning to LF transfer.

When transfer measures are based on accuracy, adults show perfect trials for the RH to LH, RF to LH, and the LF to RH direction, while children show the smallest mean error score for the LF to LH direction. For both age groups, hands placed in the transfer position obtain better transfer accuracy scores than do feet in this position. Again, for both groups the hand making the best initial accuracy record obtains the best transfer score.

Children make the poorest transfer record for accuracy when going from LH learning to LF transfer, while adults make their poorest record for the RH to LF direction. In both cases the LF shows the poorest transfer measure for accuracy.

Pattern variation

The four transfer situations used, namely: (1) transfer to the same pattern and the same side of the body as used in learning, (2) transfer to the opposite pattern and the opposite side of the body from that used in learning, (3) transfer to the same pattern but the opposite side of the body from that used in learning and (4) transfer to the opposite pattern but the same side of the body as used in learning show markedly different effects as based on speed and accuracy, as will be seen from table 6. The lowest speed and the greatest accuracy records were obtained when the transfer trial was taken on the *opposite pattern* and with the *opposite side* of the body from that used for learning. The highest speed, and the poorest accuracy scores were made when the transfer trial was taken on the *same pattern* and the *same side* of the body as used in learning. Situations three and four take the intermediate positions and obtain practically identical results.

TABLE 6

Mean transfer speed and error scores for children grouped on basis of 4 different transfer situations

SITUATION	M SCORES	
	Speed	Error
1. Same pattern and same side of body	1.808	20.2
2. Same pattern and opposite side of body	0.932	7.0
3. Same side of body and opposite pattern	0.875	7.6
4. Opposite side of body and opposite pattern	0.801	5.61

Sex differences

Analysis of children's data on the basis of sex and age shows small and inconsistent differences.

Inter-correlations

Intercorrelations between the variables of *initial speed, final speed, initial error, number of trials taken for learning, I. Q.*, and *transfer scores* yield coefficients of very low order, ranging from .51 ±.11 between initial speed and I. Q. to −.02 ±.09 between transfer speed and I. Q. The correlation between the number of trials taken for learning and initial error is .38 −.09 indicating a tendency for subjects making the highest initial errors to take more trials for learning.

Error elimination

An analysis was made of the frequency with which individual culs-de-sac were entered, and also of the total number of retracing and cul-de-sac entrance errors for each of the two bilateral halves of the maze separately. No consistent sex or age differences for children were found on this basis.

For both age groups more errors are made on the first half of the maze pattern regardless of whether the true pattern or its mirror image is learned. The data are given in table 7. In terms of overlapping, 33 per cent of the cases reached or exceeded in the tracing of the second half of the maze the number of errors made on the first half. In terms of retracing errors, the second half of the pattern showed less than fifty per cent of the total retracing errors made on the first half of the pattern.

TABLE 7

Total errors for the two bi-lateral halves of the maze patterns for boys and girls; for true pattern and mirror image; for "own" and "opposite" side learning, and totals for each type of error

	FIRST HALF	SECOND HALF	TOTAL
Boys	4,410	3,151	7,561
Girls	4,623	2,980	7,891
Own Side	4,389	3,502	7,891
Opposite Side	4,644	2,629	7,273
True Pattern	5,425	3,851	9,276
Mirror Pattern	3,608	2,280	5,888
Three Error Types:			
Retracing	2,409	1,032	3,441
Stem of T	2,966	2,225	5,191
Bar of T	3,658	2,874	6,532
Total Errors	9,033	6,131	15,164

In the analysis of the frequency of culs-de-sac entrance certain blinds show definitely higher frequencies than do others. This holds for the true pattern and the mirror image alike. For the individual culs-de-sac leading in the horizontal direction, frequency of entrance does not prove to be a matter of right or left direction as such. Analysis of the data for children shows the six most frequently entered culs-de-sac to lead more nearly in the goal direction than do the true paths immediately following. The three blinds

showing highest frequency of entrance lie within the first half of the pattern; the second group of three, showing high entrance frequencies, lie in the second half of the pattern. These statements hold for the analysis of adult data with one exception. Cul-de-sac No. 1, which represents the less direct route to the goal, is included in the group of three culs-de-sac most frequently entered, and the difficulty it presents cannot be explained in terms of "goal-direction."

no apparent significance except that the foot failed more frequently when in the second or third position. For speed scores the RF in the learning position shows the best results for each of the idle limbs regardless of whether the transfer limb is the first, or the second, or the third member to take a trial. For accuracy the LF and RH in the learning positions produce the best effects for transfer members—the LF learning showing the best results for the RH and RF, and the RH

TABLE 8

Means of transfer scores based on speed and error scores for children

	LEARNING MEMBER	TRANSFER					
		First limb		Second limb		Third Limb	
		Speed	Error	Speed	Error	Speed	Error
1	RH	.96 LH	5.2	.33 LF	35.0	.43 RF	30.8
2		.32 RF	51.4	1.39 LH	1.25	.42 LF	43.0
3	LH	1.25 RH	2.71	.37 RF	3 fail	.28 LF	3 fail
4		.35 LF	37.0	1.18 RH	3.3	.34 RF	3 fail
5	RF	.55 LF	6.16	1.18 LH	3.0	1.22 RH	2.5
6		1.43 RH	5.25	.85 LF	2.0	1.46 LH	1.5
7	LF	.56 RF	7.83	.90 RH	3.1	1.11 LH	2.2
8		.99 LH	0.5	.59 RF	13.0	1.37 RH	1.5

Position of limbs in the transfer sequence

Although the small number of adult cases prohibited an analysis of second and third idle limb transfer measures, such analysis was made for children. In the latter case each of the idle limbs was given a transfer trial following the sequence given under *method*. See table 8. The position of a transfer member in the sequence—that is its being the first, or the second or the third limb to produce the tracing—had learning giving the best transfer score for the LH and LF.

Transfer scores equated

An attempt was made to ascertain the transfer effects when the initial scores of the four limbs are identical. (See table 9 and figures 5 and 6.) Because of the large number of foot failures this procedure could be applied to speed scores only. For this purpose the constant speed score of one inch per second of time was established.

Having obtained the factor that would reduce the initial of each limb to the same factors. This procedure was carried out first to show results when

TABLE 9

Transfer speed and error scores grouped to show differences when learning and when transfer members are held constant

(1) LEARNING MEMBER CONSTANT			(2) TRANSFER MEMBER CONSTANT		
	Speed	Error		Speed	Error
RH to LH	.96	5.2	LH to RH	1.25	2.71
RH to RF	.32	51.4	RF to RH	1.43	5.25
LH to RH	1.25	2.71	RH to LH	.96	5.2
LH to LF	.35	37.0	LF to LH	.99	00.5
RF to LF	.56	6.16	RH to RF	.32	51.4
RF to RH	1.43	5.25	LF to RF	.56	7.83
LF to RF	.56	7.83	LH to LF	.35	37.0
LF to LH	.99	0.5	RF to LF	.55	6.16

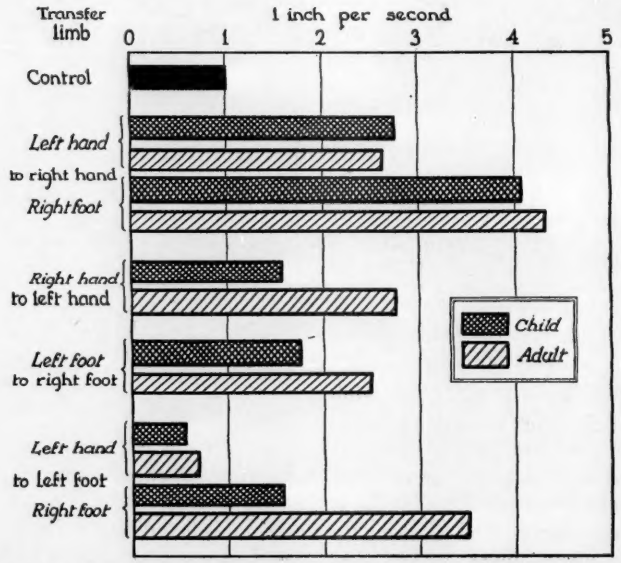

FIG. 5. FIRST TRANSFER SPEED SCORES FOR CHILDREN AND ADULTS EQUATED TO A COMMON SCORE FOR THE LEARNING LIMB. (TRANSFER LIMB HELD CONSTANT)

constant score of 1.0, the respective transfer scores were multiplied by the all *learning* members were given the same initial scores, and second when

all members in the *transfer* position were given the same initial score. This procedure doubtlessly has its limitations since the number of cases used is so small, but an interesting difference appears between results obtained. When the transfer members are given the same initial speed score, but scores for learning members vary, the transfer scores obtained by each hand and foot are remarkably more constant than is true when all learning members have the same initial scores, but transfer members vary in initial efficiency.

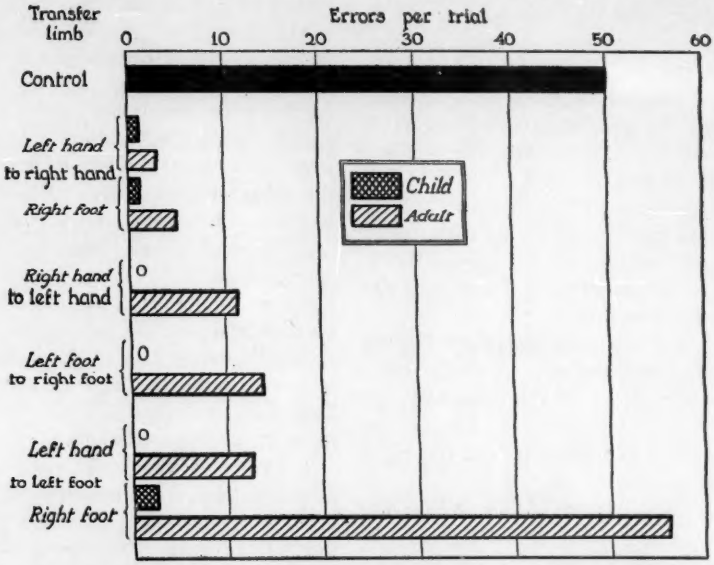

FIG. 6. FIRST TRANSFER ERROR SCORES FOR CHILDREN AND ADULTS, EQUATED TO A COMMON SCORE FOR THE TRANSFER LIMB. (TRANSFER LIMB HELD CONSTANT)

Goal position and transfer scores

In the two maze patterns used, the true pattern had the starting point located at the lower right-hand corner, and the goal post at the lower left-hand corner. The bi-lateral mirror image reversed the positions of the two posts. A comparison of performance on the two patterns shows more errors made on the true pattern by both adults and children. No constant difference is shown for speed on the two patterns.

Learning from the limbs "own" side was differentiated from learning that started from the "opposite" side. The right side of the body is shown to make more errors when it starts from its "own" side and the left side of the body when it starts from the "opposite" side. This merely reinforces the statement just made, namely, that more errors are made on the "true" pattern by both age groups. In every instance, greater accuracy is shown for the clockwise as opposed to the counter-clockwise movement.

For speed, both age groups obtain higher scores for initial and final trials when tracing begins from the limbs "own" side.

On the basis of these findings the following conclusions seem justifiable:

1. Speed is always greater for hands than for feet, and always indicates a condition of "cross-gaitedness" by showing the superior hand to be diagonally opposite the superior foot. An inverse relationship between the development of speed and accuracy holds for the right hand. The hand of greater initial speed makes the smallest relative gain in speed. The right foot has the greatest capacity for gain in speed, and the right hand the greatest capacity for gain in accuracy. Hands have greater capacity for gaining accuracy than do feet.

2. Greater accuracy is shown for the right side of the body for children and the left side for adults. Relative gain of speed is greater for the left side of the body for children, and the right side for adults.

3. Initial speed, ability to improve in accuracy, and the differences in speed and accuracy between the right hand and other limbs increase markedly with age and experience. Initial accuracy, the ability to improve in speed, and the number of trials taken for learning decrease with age and experience.

4. Practice decreases age differences in speed, and speed differences between the two hands. It also decreases speed differences between the right foot and the left foot for adults, but increases these differences in children.

5. Transfer speed and accuracy scores are affected by change in pattern, limbs, and sides of the body used. Accuracy and speed are to some degree at least dependent upon the position of the starting point of the maze in relation to the hand or foot used for learning. Greater speed is always obtained when the limb begins at its "own" side of the pattern.

The amount of transfer coming to an idle limb, and the amount coming from a given learning limb vary according to the direction taken. Better positive effects are always obtained when going from the less efficient to the more efficient limb. (Efficiency in this case is based on initial trials.)

6. Transfer scores show positive speed and accuracy effects for all idle limbs of adults. For children both positive and negative effects are obtained; the right foot in the learning position results in the best transfer scores for each of the idle limbs. Transfer scores improve with age.

7. Errors for this study appear to be a function of the direction of the culs-de-sac, and their positions relative to the goal. Culs-de-sac showing the greatest number of entrances lead most directly to the goal. Goal direction is learned before distance or total maze form. Form is learned before distance. Learning, progressing clockwise, shows greater accuracy than the counter-clockwise movement.

8. Up to a certain level of efficiency an increase of speed appears to be accompanied by an increase in accuracy. Beyond this level increase of speed appears to be developed at the expense of accuracy. This indicates that greater skill in movement, with its accompany-

ing confidence, produces greater inaccuracy. This does not appear to condition the capacity for improvement through practice. This suggestion follows: that early emphasis upon accuracy for the purpose of developing necessary caution may be the best practice in motor learning.

9. The size of the transfer score seems to be determined in a large measure by the efficiency of the transfer limb, and to a lesser degree by the amount of effort exerted by the learning limb. It would appear from this that where transfer in motor learning is desired, training of the least efficient limb is most economical.

10. Adults appear to make a transfer-tracing with little or no attention to sensory cues. A lack of positive transfer may then be largely a matter of close attention, and therefore a reverting to the earlier learning stages of the specific problem. The lack of positive transfer would be then, to some degree at least, a matter of adjustment. Greater experience and general practice as demonstrated by the adult group in this study tends to produce greater ability for improvement and better transfer scores. These differences are markedly greater when the adult right hand—the hand of most highly differentiated practice—is compared with the other limbs. For children, hands learn more quickly than do feet, and the right hand shows ability for greatest improvement.

11. These facts appear to indicate clearly that training operating in the learning of this problem was of a general rather than a specific nature.

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Brief Reports

Comprehension of Some Sizes, Shapes, and Positions by Young Children[1]

STUDIES of language comprehension have been meager and for the most part confined to short items in intelligence tests, measuring the comprehension among children of objects or activities which are constantly in their environment. Practically the entire story may be found among items in the Kuhlmann and Stanford revisions of the Binet test, those included in Gesell's and Descoeudres' norms, and more adequately in the recently published tests of Van Alstyne. On the other hand, studies of the *use* of language have been considerably in number. The present investigation is an attempt to bridge the gap ever so little between our knowledge of language usage and of language comprehension among preschool children. It was undertaken specifically to discover what sizes, shapes, and positions commonly known to adults are comprehended by young children and to devise methods for determining this. To this purpose two simple experiments were contrived.

PART I

The first experiment consisted of two four-page booklets, one of which was the duplicate of the other. On each page were pasted 6 bright blue figures such as squares, diamonds, half-moons, stars, triangles, crosses, circles. Five of these items appeared in both the vertical and horizontal positions. The experimenter kept one booklet and gave the other to the child with the instructions:

"I am going to play a game with you. Here are two books—one for you and one for me. They are just alike. See? (E opens both books and shows S the similarity) I am going to try to fool you, but don't you let me. You point to the one that I NAME, and not to the one that I point to. Do you understand? I am going to point to the wrong one, just to try to catch you. Now you be sure to point to the one that I NAME. Ready! Point to the diamond."

This game is similar to one played in the University kindergarten in which the teacher gives a command and expects the children to do as she says and not as she does.

The experiment was given to 33 kindergarten children at the Institute of Child Welfare, University of Minnesota; it was repeated on 20 of these children for the purpose of computing reliability. One point was given for each correct response. Scores on the initial test range from five to nineteen out of a possible 24 with a median score of 11. There was no correlation

[1] From The Institute of Child Welfare, The University of Minnesota.

between initial scores and IQ's in this restricted age group.

Consistency as measured by the percentage of identically correct responses on the retest ranged from 78 per cent to 100 per cent with a median of 90.5 per cent. The consistency when wrong items were included ranged from 33 per cent to 79 per cent with a median of 60 per cent, a result suggesting that although there was a high degree of reliability on the items that were really known, there was little consistency in confusion or error on the unknown items.

The percentage of correct responses for each item are given in table 1, together with a percentage of consistently correct responses given by the 20 retest subjects. The items that are known to an extent of 60 per cent or better by these kindergarten children are the moon (crescent), the half-moon, the star, the cross, the circle, square, and diamond, and all of these items were consistently correct for more than 90 per cent of the retest group. The small percentage of recognition and the lack of consistency on the pyramid, the wavy and jagged lines, the vertical oblong, triangles, and the cylinder and hexagon indi-

TABLE 1

Part I. Per cent correct responses and item-consistency

ITEMS	ORIGINAL TEST (33 SUBJECTS) PER CENT CORRECT RESPONSES	RETEST (20 SUBJECTS) PER CENT CONSISTENTLY CORRECT
Moon (vert. crescent)	100	100
Star	100	100
Half-moon (vert.)	91	100
Moon (horiz. crescent)	88	100
Cross	82	100
Half-moon (horiz.)	73	100
Circle	67	100
Diamond (vert.)	64	100
Square	64	93
Diamond (horiz.)	61	93
Slanting line	42	64
Oval (vert.)	42	70
Pyramid	36	56
Wavy line	36	40
Triangle (scalene)	36	75
Oblong (vert.)	28	57
Jagged line	24	40
Oblong (horiz.)	22	66
Oval (horiz.)	22	66
Triangle (rt. angle)	18	100
Cone	15	100
Triangle (Isosceles)	15	66
Cylinder	13	0
Hexagon	12	0

cate that these items were not known by the group. On the other hand, all of the items except the cylinder and hexagon were known, and consistently so, by two or more children, indicating that the ability to recognize these shapes is present in some five-year-old children.

In every case the vertically placed items were known by a larger per cent of the subjects than the horizontally placed ones.

The reliability of this method for measuring comprehension is high enough to warrant further experimentation with it or with some similar method, such as that of Van Alstyne. The application of the method with children under the kindergarten level has not been determined because the items included in this test were too difficult for use below that age.

PART II

The second experiment on comprehension was one where in a sand table was arranged with a forest scene including hills, lakes, a fence, a bridge, a teddy bear and other items of interest to the child. A story about the adventures of the teddy bear was told to each child, and he was asked to make the teddy bear do what the story indicated. The following is a sample of the story, which contained twenty-five words of position, size, and shape:

"Once upon a time Jack Bear stood beside the tree where he lived, and thought, 'I'm tired of staying here all the time. I wonder if I can find a nice place to go where I can have some fun!' While he was thinking hard about it, he jumped *forwards* and he jumped *backwards*. (Will you make him jump forwards? And make him jump backwards?). . . . He started out on his journey and soon decided that he needed a walking stick. . . . There were so many sticks there that at first he didn't know which one to take. . . . He looked them all over, and then picked up the *crooked* one. (Will you pick out the crooked one for him?) 'I don't want that,' he said, and laid it *behind* him. . . . " etc.

After each critical work or phrase the experimenter paused and asked the child to make the teddy bear perform the act. If the child did not comply immediately the experimenter repeated the request twice and then went on with the story. The reliability of the method was checked by a second story about the adventures of a boy and girl doll, one of which the child manipulated in the appropriate ways. The same toys and objects were used, but the scene was given variety by a rearrangement of them; the same critical words were introduced into the story in a different order.

The teddy bear story was told to 40 kindergarten and nursery school children at the University of Minnesota, and the second, in order to estimate reliability, to 14 of these children. The initial scores ranged from five to twenty-five out of a possible 25, with a median of 18. The median percentage of consistency by items was 86 per cent; the median consistency for the 14 subjects, 83 per cent. This indicates that one administration of a test of this sort gives fairly reliable information as to the child's knowledge of these words.

In table 2 the percentage of correct responses on the initial test is given by age levels, and also the percentage consistently correct for the retest subjects. The italicized figures represent the items passed by 60 per cent or more

of the subjects. It is significant that every item known by the three-year-olds is also known by the four- and five-year-olds, and similarly, that every item known by the four-year-olds is also known by the five-year-olds. Furthermore, in general the items are recognized in an increasing percentage of the cases at the higher age levels. The items not passed by any age group were, "rough," "narrow," "broad," "far," "near." "Shallow" and "smooth," however, do not show a high consistency.

TABLE 2

Part II. Items recognized, by C.A. distribution: 60 per cent or above correct indicated by italics

	ITEMS	PER CENT CORRECT, INITIAL TRIAL			PER CENT CONSISTENTLY CORRECT (14 SUBJECTS)
		30 to 41 months, 6 subjects	42 to 53 months, 10 subjects	54 to 68 months, 24 subjects	
	over	*100*	*100*	*96*	92
	big	*100*	*100*	*100*	100
	crooked	*83*	*60*	*100*	86
	under	*83*	*80*	*100*	92
	high	*83*	*90*	*100*	100
	long	*67*	*80*	*100*	92
	tall	*67*	*90*	*100*	100
	thin	*67*	*90*	*88*	92
1					
	on top	50	*90*	*96*	100
	behind	33	*80*	*100*	92
	bumpy	33	*80*	*96*	92
	deep	17	*80*	*92*	71
	pointed	33	*70*	*100*	86
	shallow	50	*60*	*75*	57
2					
	few	17	20	*92*	79
	forwards	33	30	*88*	79
	backwards	33	30	*88*	71
	tiny	17	50	*88*	86
	smooth	17	40	*75*	57
	hugh	0	30	*63*	79
3					
	rough	17	30	59	86
	narrow	17	20	55	86
	broad	0	40	25	79
	far	0	20	50	71
	near	0	20	41	71

All items above 1 were passed by 3-year-olds; all items above 2 were passed by 4-year-olds; all items above 3 were passed by 5-year-olds; all items below 3 were not passed by any group.

From the standpoint of motivation this experiment is excellent; in fact, the experimenter was not able to enter the playrooms without being assailed by some child who wanted to play with her.

In the second method the number of alternatives for each "test" item was not constant; there were, for example, four sticks to test "long," "crooked," "pointed," and only two boards, a narrow and a wide one, to test "narrow." The technique should be further developed, then, to include at least four alternatives at each choice-situation. It seems advisable to the experimenter, too, that a series of entirely different test-situations should be set up to validate the measures obtained with this method. Significant possibilities would seem to be offered by th e use of this method for other investigations of meaning in young children.

Both parts of this experiment give a reliable instrument for determining language comprehension, the first useful for kindergarten children, and the second for both nursery school and kindergarten children, above the age of two and one-half years.

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A Study of Thumbsucking in Infants from Two to Seventeen Weeks of Age[1]

THUMBSUCKING is a subject on which there is much discussion, but little investigation. The literature on the subject is scarce, based in the main only on general observation, and sometimes contradictory.

The best study is that of Lewis and Lehman (8, 9) which is based on the observation of 170 children and covers a period of five years. It was possible to observe the children over the entire nursery school period of three years, and to make casts of their dentition. It was found that 30 of the children sucked their thumbs. All but 2 contracted the habit in the first year of life, and 9 sucked practically from birth. The time of breaking the habit ranged from nine months to six years. There was a definite preference for the right thumb. All of these children sucked their thumbs at bedtime, and less frequently when engaged in various activities. A comparison of the casts of the dentition made over a period of years shows that in 24 cases there was a definite malocclusion of the deciduous teeth. If the habit were corrected before the age of 6 years, the malocclusion tended to correct itself; if not, the malocclusion tended to remain static. The malocclusion always showed a forward displacement of the premaxillary bone and of the upper incisors, with an occasional reclusion of the lower in-

[1] From the Institute of Child Welfare, University of Minnesota.

cisors. The displacement was always toward the side of the thumb sucked, and if both thumbs were sucked, the displacement was symmetrical.

The literature on thumbsucking may be summarized briefly under three heads. As to the frequency, onset, and persistency of the habit, thumbsucking may be considered a normal behavior type for very young infants. It is often present from birth, is generally contracted in the first year of life, and may have its beginnings in the random movements of the child. It decreases with age, being most common under 6 years. It is classified as a sensory-satisfying habit, and is more common with nervous children, as they contract the habit earlier and are harder to break.

The detrimental results which are said to result from thumbsucking are drooling, malocclusion of the deciduous teeth, and possible malocclusion of the permanent teeth if the habit is not broken before 6 years of age.

To break the habit in very young children, gently remove the hand from the mouth and give the child something to hold. With older children, an appeal to pride is most effective. The use of a cuff or wire "sleeve," taking the child away from his play to suck his thumb in front of a mirror for 10 minutes, psychoanalysis, taking toys to hold when going to bed, holding the bedclothes, and positive suggestion are the best remedies.

The present study has for its purpose to discover how early in life thumbsucking appears as a definite habit. Subsidiary to this problem is the question as to whether or not there are typical hand, arm, and mouth activities in early infancy.

The subjects of the study were 25 babies, 10 boys and 15 girls, who were observed at a maternity home for unmarried mothers.[2] The infants ranged in age from fifteen days to seventeen weeks. The total number of observations recorded is 354. There is an average of twenty-five to 40 observations at each age level from three to fourteen weeks.

OBSERVING THE INFANTS

After two preliminary visits, the experimenter listed the activities she wished to observe, and devised a code and record sheet. This code, which was memorized, is listed below with the definitions.

Position of arms: U. C. under cover; D. down; Chest. the arms in such a position that the hands would be resting between the baby's waist and chin, and the arms close to the body or on it; Up. the arms held close to the body, and the hands lying between the chin and the top of the head; Ohd. the arms close to the body, the hands resting above the level of the top of the head; S. the arms stretched toward the sides of the crib.

Movement of arms: Rand. the seemingly aimless waving movements of the arms; Q. the arms quiet; Stretch. Stretching.

Hands: Ball. flat closed; Curl. the slightly flexed position of hand; Spread. the fingers spread out, and the hand quite definitely flat; Clasp. the hand clutching something; Rub. rubbing, the hand being either ball, curl, or spread, this being recorded separately; Rand. F. a seemingly aimless finger movement.

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[2] The writer thanks the matron and nurses of the St. Paul Salvation Army Maternity Hospital for Girls for their coöperation in the study.

Mouth and sucking activities: Smi. smiling; Op. Q. mouth open and quiet; Clo. Q. mouth closed and quiet; Cry. crying; Voc. vocalizing, cooing, grunting, sounds other than crying; Hic. hiccup; Y. yawning; Sn. sneezing; Cough. coughing; L. lip sucking, the lower lip being drawn in slightly and sucked; Tg. tongue sucking; Ch. chewing movement of mouth; C. cuff sucking; Mit. sucking mitten that has been placed over the hand as a training device; Cov. sucking covers of crib; T. sucking thumb; 1, 2, 3, 4, sucking fingers, numbered beginning with the index finger; F. sucking fist; B. blowing bubbles between lips.

The record sheet provided space to record whether the baby was awake or asleep, the activities of the right and left hands, and the mouth, in addition to date, time of the observation, and age in weeks. Timing was by stopwatch.

Each baby was observed twice in one day, on an average of 2 days a week. Each observation lasted 30 seconds, and there was an interval of about fifteen minutes between the 2 observations. All observations were made between three and four in the afternoon, the feeding periods being at two and five, and the babies were taken up only once in this interval, for changing.

The observations of the experimenter were checked by comparing them with those of a second observer who made three visits to the hospital, and observed simultaneously and independently. There was 76 per cent agreement between the records, 14 per cent disagreement, and an omission of 10 per cent on the part of the second observer.

ARM AND MOUTH HABITS

Thumbsucking and mouth activities

Of the 25 babies in this study, 11, or 44 per cent sucked their thumbs, fingers, or fists at least once during this series of observations. Finger-sucking was noted 50 times in the entire series, and at every level from three to seventeen weeks. Finger-sucking occurred in 14 per cent of the total number of observations. There is a definite preference for the right thumb (28 cases), with the left fist ranking second (6 cases). More sucking occurred while the baby was awake (36 cases).

The most common mouth activity while the babies were awake was crying, which occurred in 52 cases out of the 263 recorded mouth activities, or 19.8 per cent. The babies had their mouths closed and quiet 42 times, or 16 per cent. The third most frequent activity was tongue sucking, noted 26 times.

In 59 per cent of the cases recorded, the babies slept with their mouths closed. In 42 per cent of the cases the mouth was open. The most frequent of the other activities was lip sucking which occurred 8 times (4 per cent).

Hand and arm activities

The "ball" position of the hands was most frequent both waking and sleeping, occurring 55 per cent and 73 per cent respectively. Clasping ranks second among the waking activities, 14 per cent. This activity appeared first at the age of 5 weeks, when there was one case with the right hand. Clasping with the left hand did not appear until the age of 8 weeks, when there were 2 cases. Rubbing appeared at 7 weeks, one case with the left hand being recorded, and it was followed by a record on both hands the very next

week. This activity occurred only 10 times (3.5 per cent). Random finger movements rank third as a waking activity, scoring 28, or 10 per cent. Sleeping activities are few, the spread and curl positions tying for second place with 10 per cent. All the other activities occurred very seldom.

The most common position of the arms, both sleeping and waking is the "up" position (56 per cent and 37 per cent); the chest position was second in preference in the waking state (34 per cent) and the under cover position in the sleeping state (22 per cent). The latter position is less frequent when the baby is awake, and in either case the position decreases with age. The side position, on the contrary, increases gradually with age. It was first noted at 5 weeks, and occurred in 10 per cent of the waking observations, and 6 per cent of the sleeping observations. The down and the overhead positions were more infrequent, occurring 3 per cent or less in either state.

It is to be expected that the baby would hold its arms quiet while sleeping, and this was found in 85 per cent of the cases recorded. It is interesting to note that stretching occurred 42 times (12 per cent) while the babies were asleep, and in only 1 case was there a stretching of one arm without a simultaneous stretching of the other arm. This activity occurred only 7 times (2 per cent) in the waking cases. The quiet position of the arms is most frequent even when the babies were awake, occurring 56 per cent of the time, with random movements second with 43 per cent.

Sleeping and waking

The number of waking observations increased with age, as was to be expected. This is especially noticeable at about seven weeks. Before the age of seven weeks, only 42.2 per cent of the observations are on babies who are awake, while above seven weeks, 61.9 per cent of the observations were made while the babies were awake. The total waking observations were 54.8 per cent.

CONCLUSIONS

1. Eleven of the babies of this study sucked their thumbs. All but one of them sucked at more than one weekly age level; thus the sucking can be considered habitual for the early period of infancy covered in this study.

2. There was a marked preference for the right thumb.

3. The most common positions of the arms for very young infants is the chest or up position described in the study.

4. Clasping, rubbing, arms stretched out to the side or overhead appeared in this study in the second month of age and appeared with increasing frequency as age advanced.

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